

Battery raw material pricing in a lithium ion era

DERA Industrieworkshop | Berlin-Spandau
June 2017

Andrew Miller, Senior Analyst
Benchmark Mineral Intelligence, UK

- www.benchmarkminerals.com
- @Benchmarkmin
- info@benchmarkminerals.com

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Lithium
Price surge slows in China, but ROW contracts play catch up

July 2016

BENCHMARK MINERAL INTELLIGENCE

Author: Andrew Miller
Analyst: Andrew Miller
Editor: Andrew Miller
Cover: Andrew Miller
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Key Highlights

- Lithium prices continue to rise as Chinese producers remain on strike
- Hydrometallurgy remains the dominant production route
- China's domestic stockpile is fast becoming a liability
- BMI Lithium Price Index up 3.5% in June, 47% ytd
- LiD lithium ion battery cathodes demand outlook strong on a bias
- China EV production up for fourth consecutive month

Key Events

- China EV production up for fourth consecutive month

Key Metrics

- China EV production up for fourth consecutive month

Key Quotes

China EV production up for fourth consecutive month

Lithium



Graphite
Price collapse continues as excess supplies prevail

February 2016

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Graphite



Cobalt
Heading here

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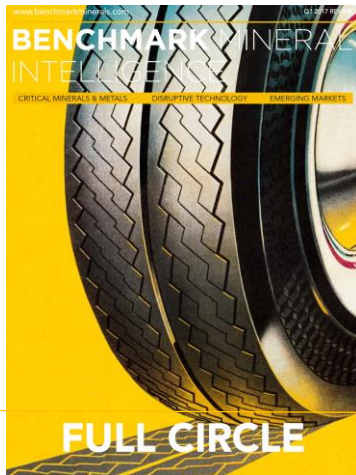
Key Metrics

- China EV production up for fourth consecutive month

Key Quotes

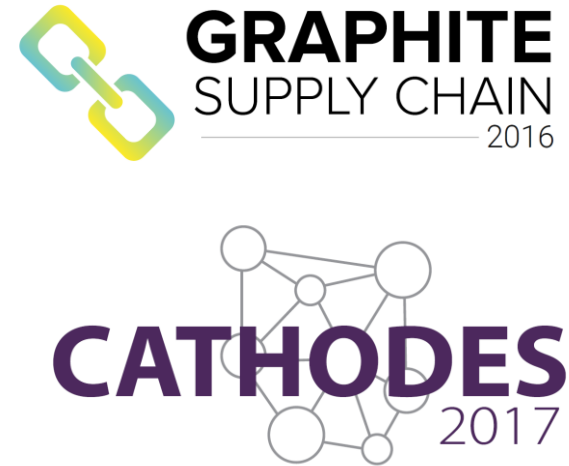
China EV production up for fourth consecutive month

Cobalt



Membership

Events



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



Now quoting basic Benchmark Mineral Intelligence prices

Lithium

BENCHMARK DATA
LITHIUM
JUNE REVIEW

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July 2016

Lithium
Price surge slows in China, but ROW contracts play catch up

- Lithium major increase prices for carbonate and hydroxide (2) contracts
- Hydroxide jumps towards 115/kg while carbonate moves north of 110/kg
- China's domestic case slow but prices stay high
- BM Lithium Price Index up 3.5% in June, 45% ytd
- Li2CO3 ton battery cathode demand outlook strong on a host of subsidies
- China's EV production up for fourth consecutive month

TERMINOLOGY

Market Background: The lithium market continues to experience a price surge in the lithium carbonate and hydroxide markets. The price surge is driven by a combination of factors, including a tight supply of lithium carbonate and hydroxide, and a strong demand for lithium carbonate and hydroxide from the lithium-ion battery cathode market. The price surge is also driven by a combination of factors, including a tight supply of lithium carbonate and hydroxide, and a strong demand for lithium carbonate and hydroxide from the lithium-ion battery cathode market.

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Graphite

BENCHMARK DATA
GRAPHITE
FEBRUARY REVIEW

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February 2016

Graphite
Price collapse continues as excess supplies prevail

- Raw material prices continue to decline as excess supplies prevail
- Benchmark Graphite Index drops a further 4.4%, down 14.3% ytd
- Several clients in China conservative regarding falling demand
- Further demand side pressures expected in Asia approaching Q2 2016
- Heavy discounts continue as producers attempt to clear stockpiles. High cost Chinese producers under pressure

TERMINOLOGY

Market Background: The graphite market continues to experience a price collapse. The price collapse is driven by a combination of factors, including a tight supply of graphite, and a strong demand for graphite from the lithium-ion battery cathode market. The price collapse is also driven by a combination of factors, including a tight supply of graphite, and a strong demand for graphite from the lithium-ion battery cathode market.

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Cobalt

BENCHMARK DATA
COBALT
MAY 2017 REVIEW

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June 2017

Cobalt
Heading here

- Stabilisation of metal prices and reduced volatility leads to dampening of cobalt sulfate prices in China, except NiO4
- China's expectations in cobalt refining capacity underway in preparation for new raw material supply from Glencore and BRIC DRC operations
- Danfoss/Wanxun Suez break ground on 3500 million battery pack facility in Foshan, Germany
- Benchmark adds 14th lithium ion battery manufacturer to its track: Dynowatt, Fujian, China @ IGMW NMC
- Benchmark estimates Dynowatt plant cobalt consumption at 2,000 tonnes annually in the NMC cath.

KEY TERMS

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Detailed prices & analysis exclusive to subscribers

How do we do this?

- First hand data collection...

Heilongjiang, Northern China



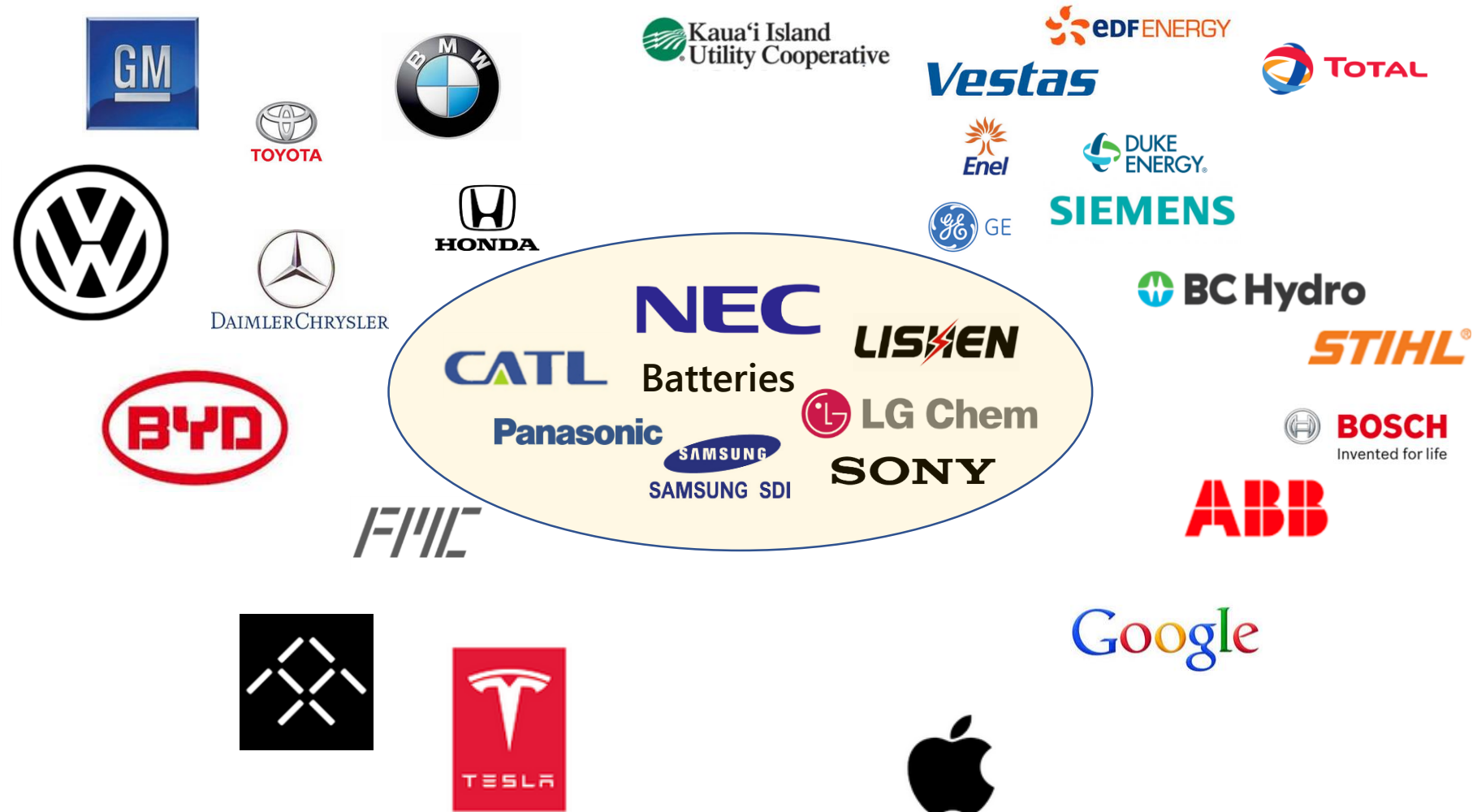
Hirschau, Germany



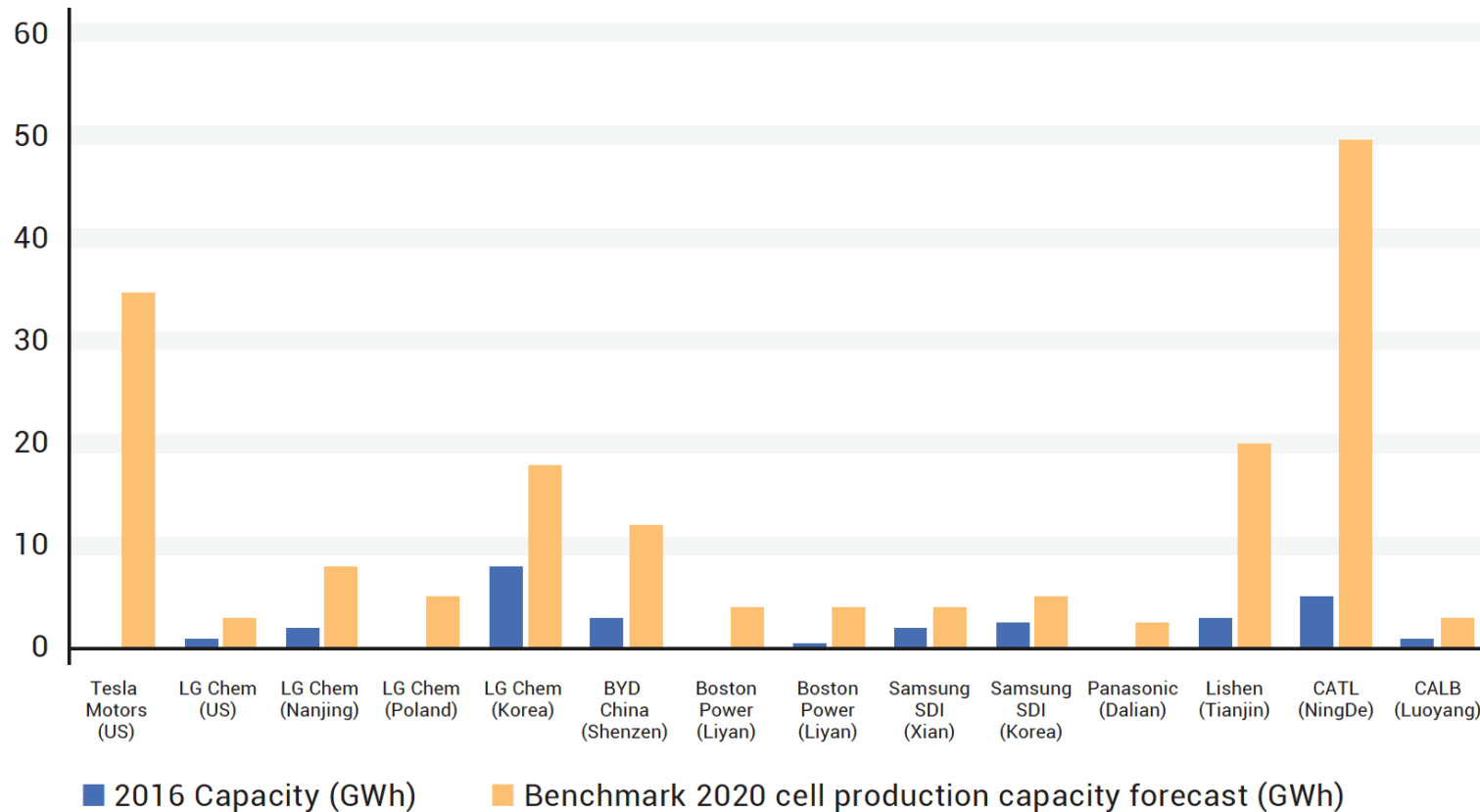
Palo Alto, California, US



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

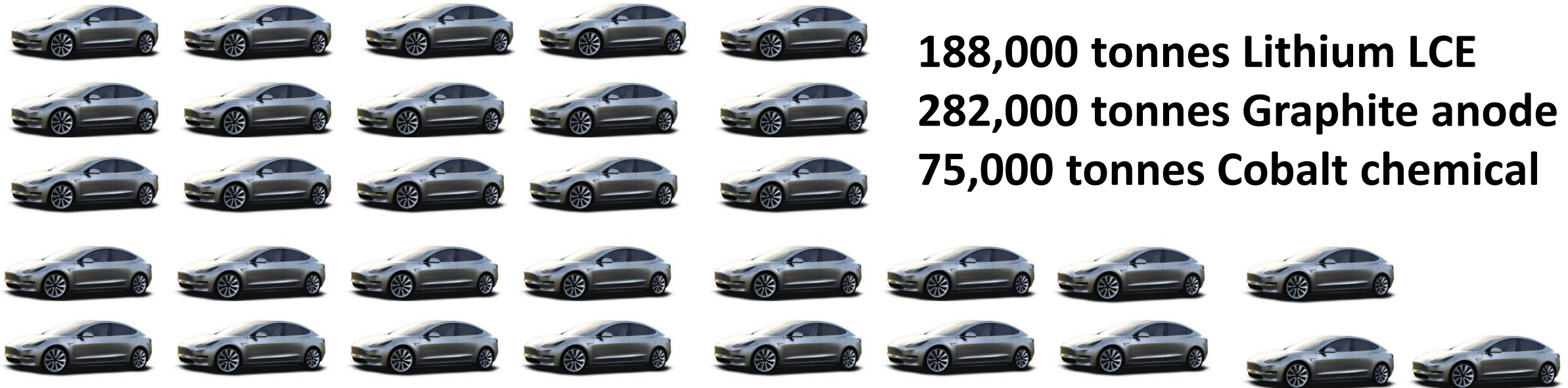
How many pure EVs can this new capacity make?

2016: 29GWh Megafactory Capacity



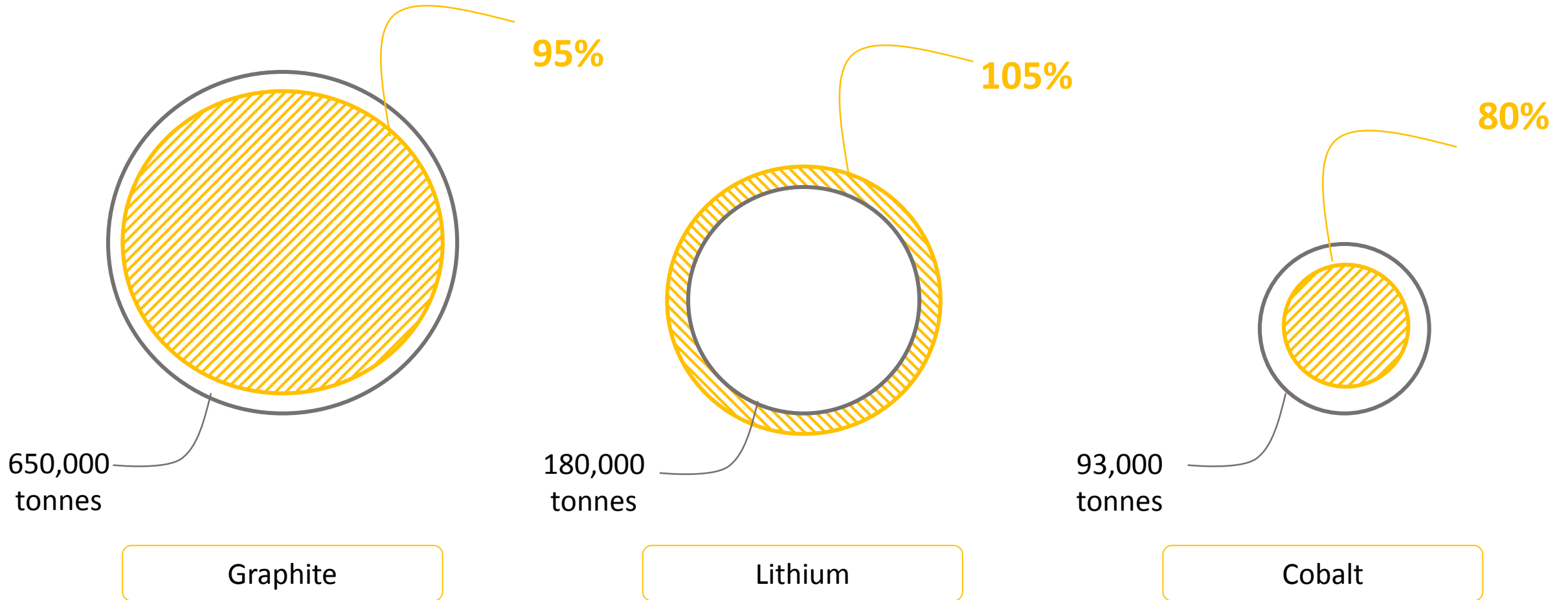
23,000 tonnes Lithium LCE
34,800 tonnes Graphite anode
9,200 tonnes Cobalt chemical


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

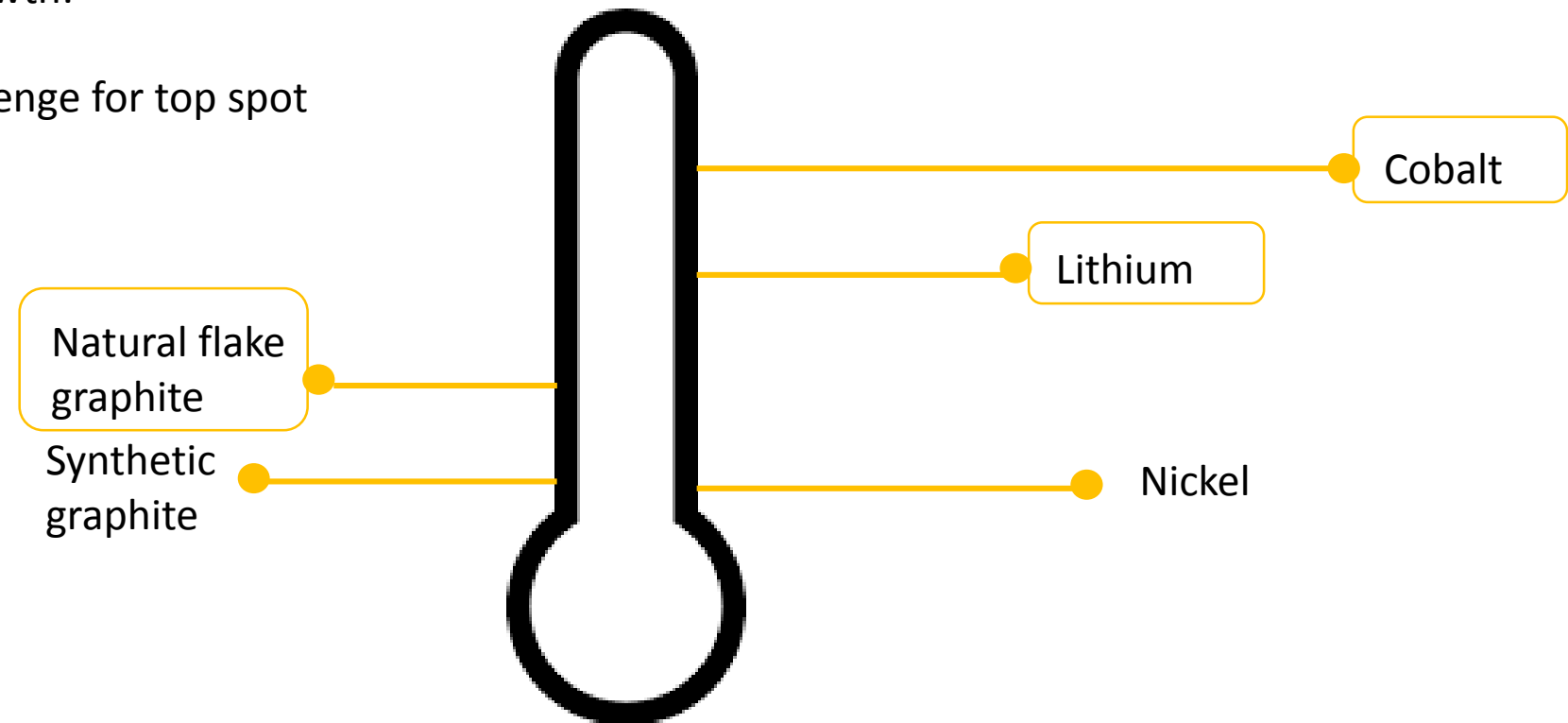




How are raw material markets evolving?

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



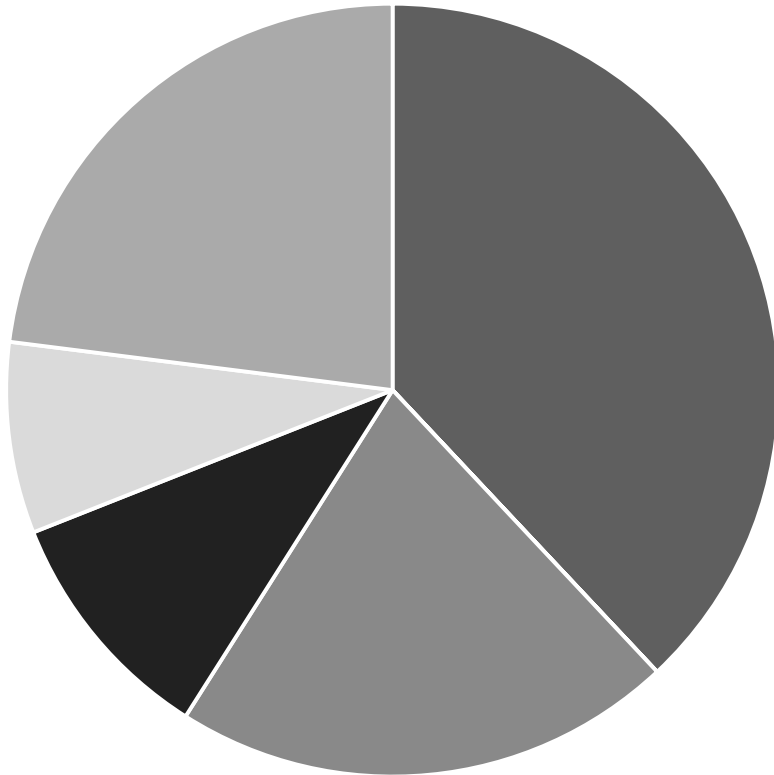


Graphite

Lithium ion batteries to challenge for top spot...

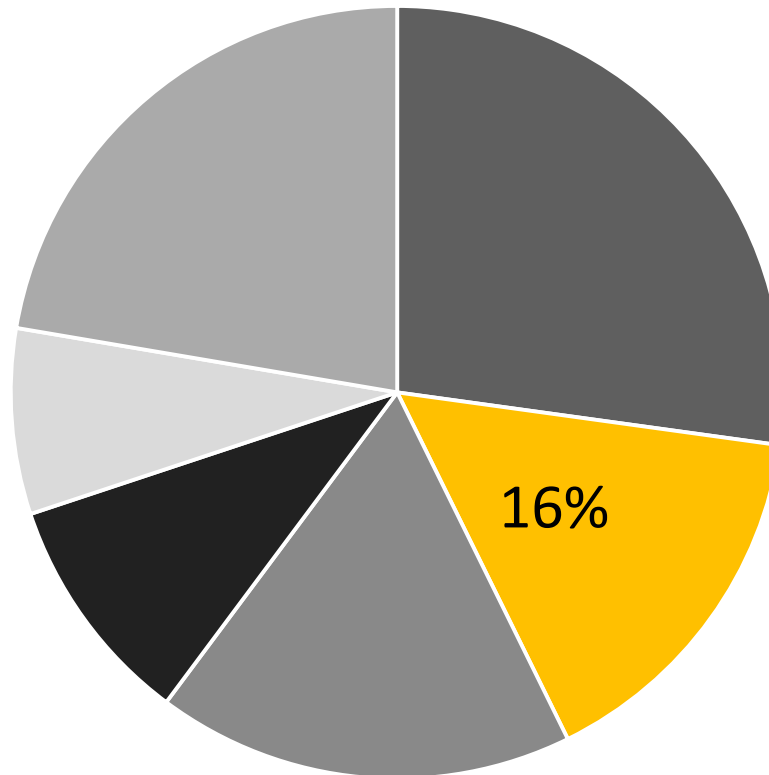
Flake Graphite's End Markets

2006



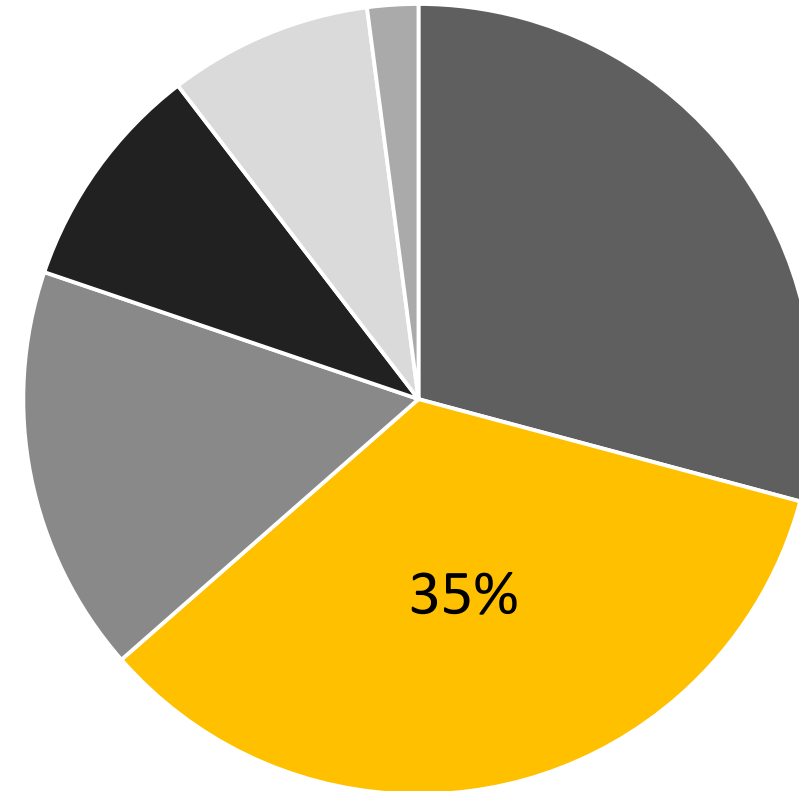
559,000 tonnes

2016



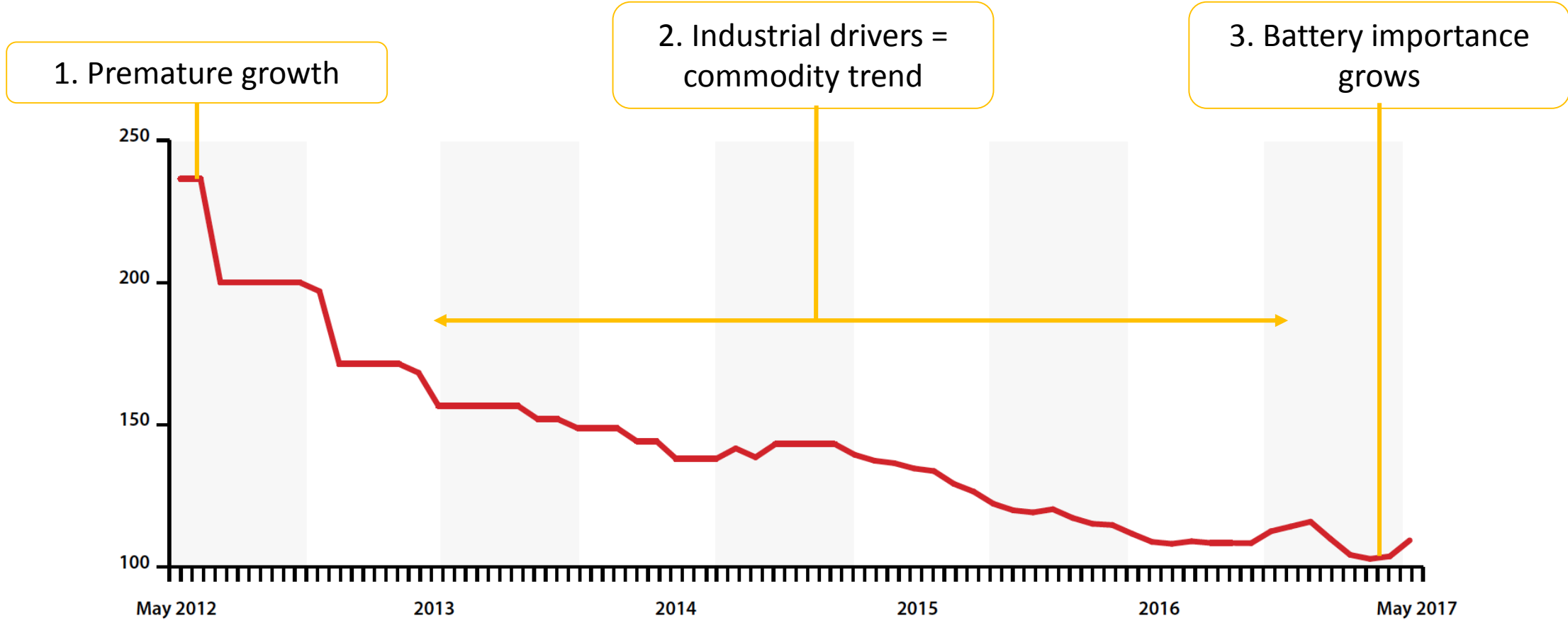
650,000 tonnes

2020



884,000 tonnes

Flake graphite price trend



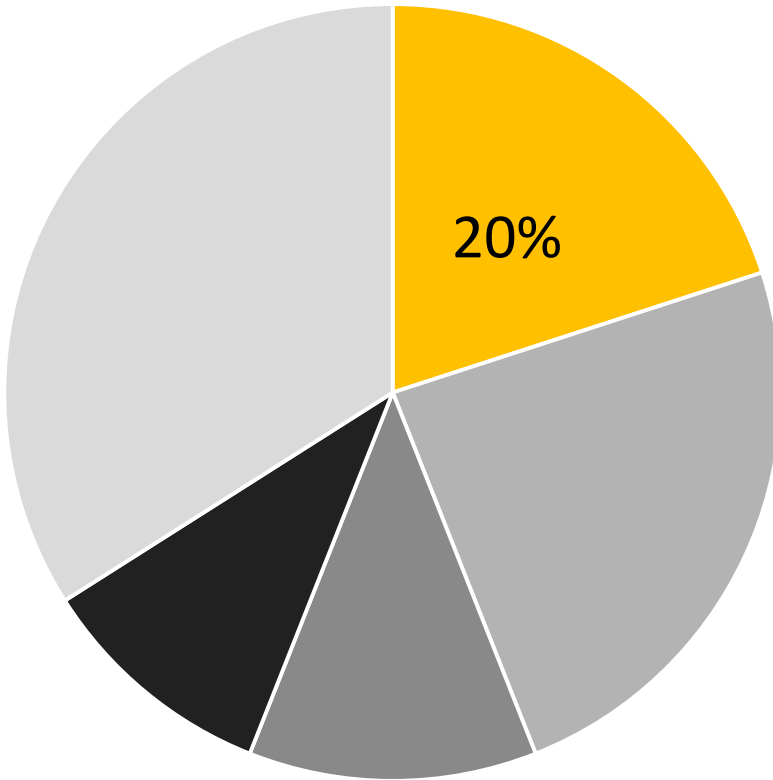
Cobalt



Lithium ion dominance to grow...

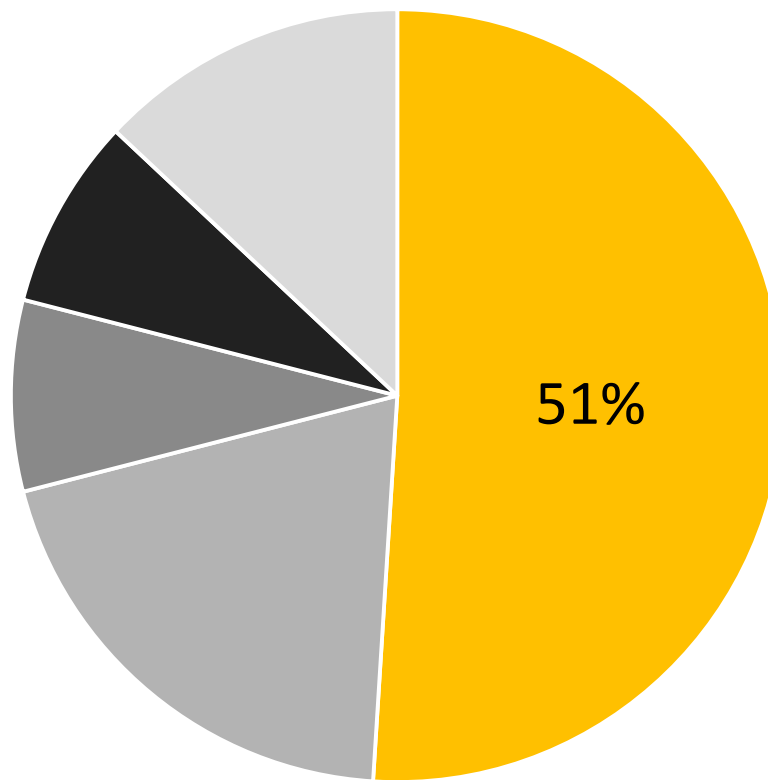
Cobalt's End Markets

2006



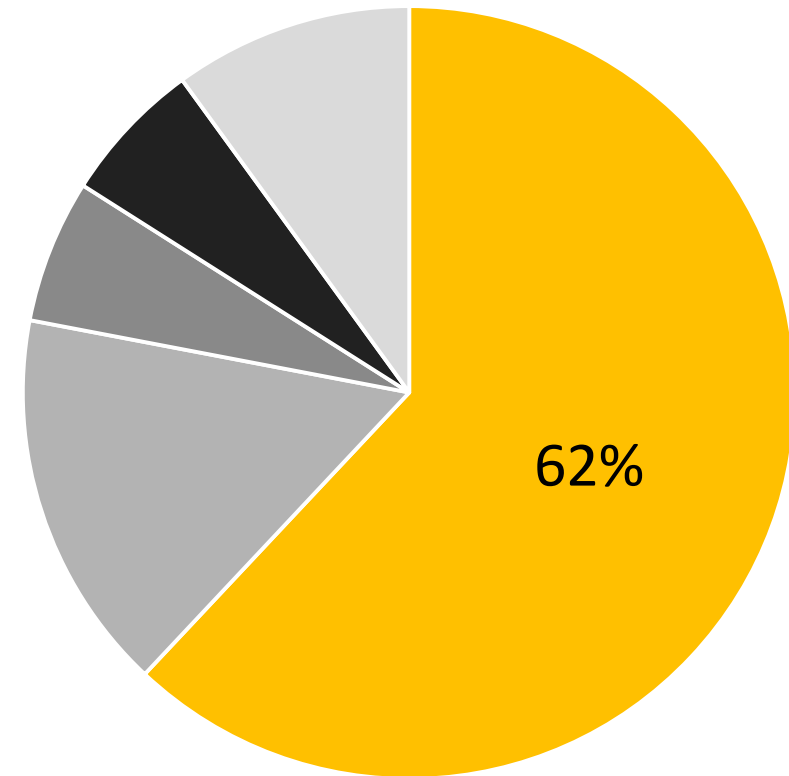
51,000 tonnes

2016



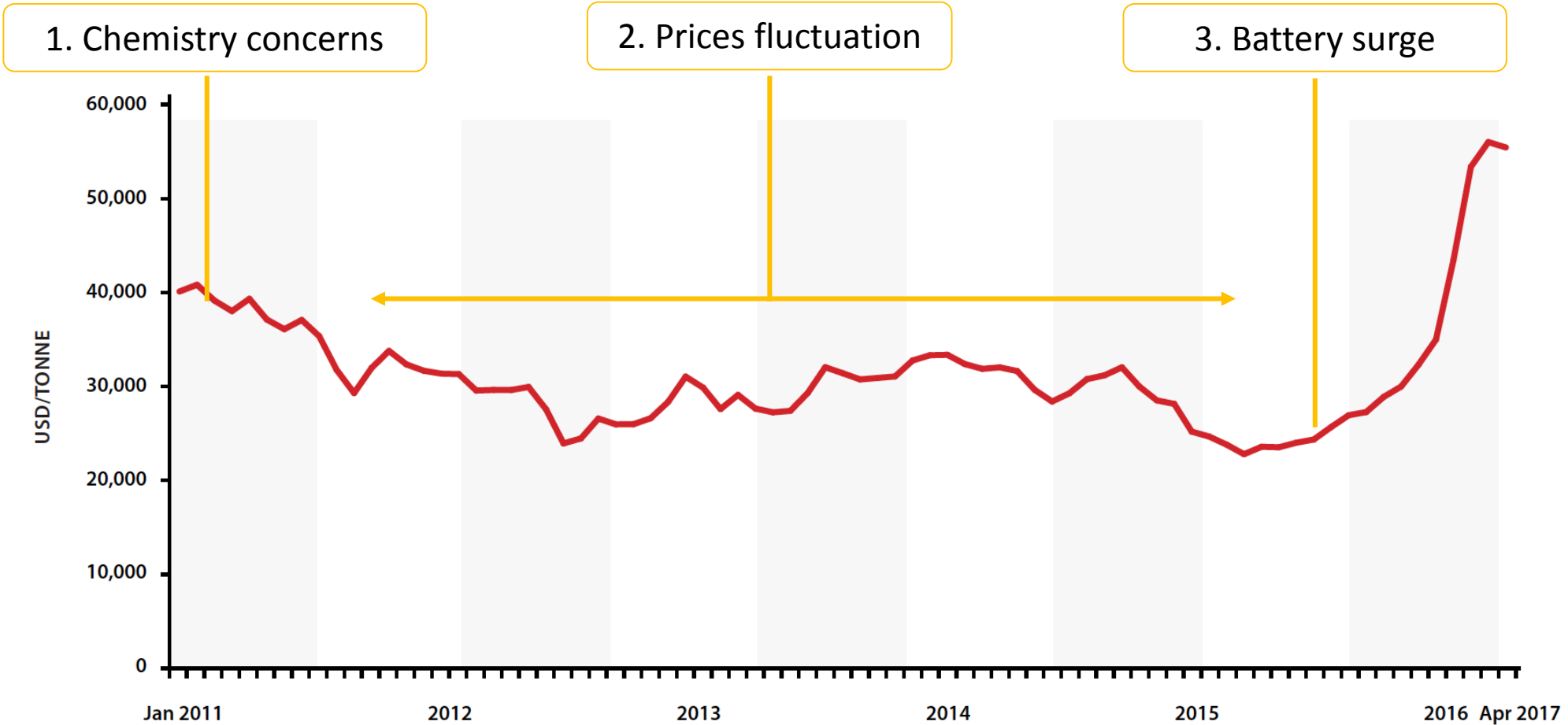
96,000 tonnes

2020



126,000 tonnes

Cobalt price trend

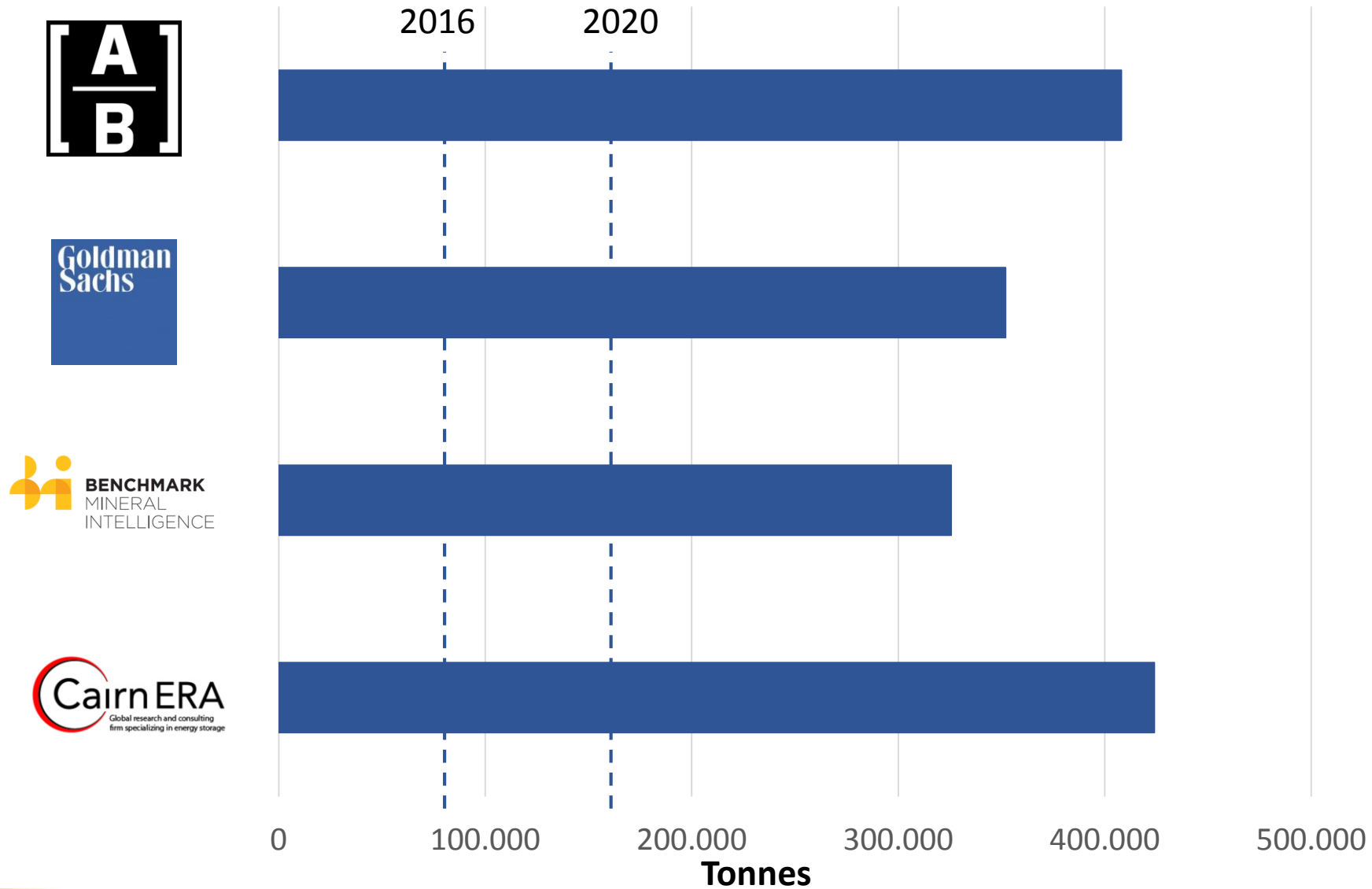




Lithium

PEDESTRIAN
ACCESS
ONLY

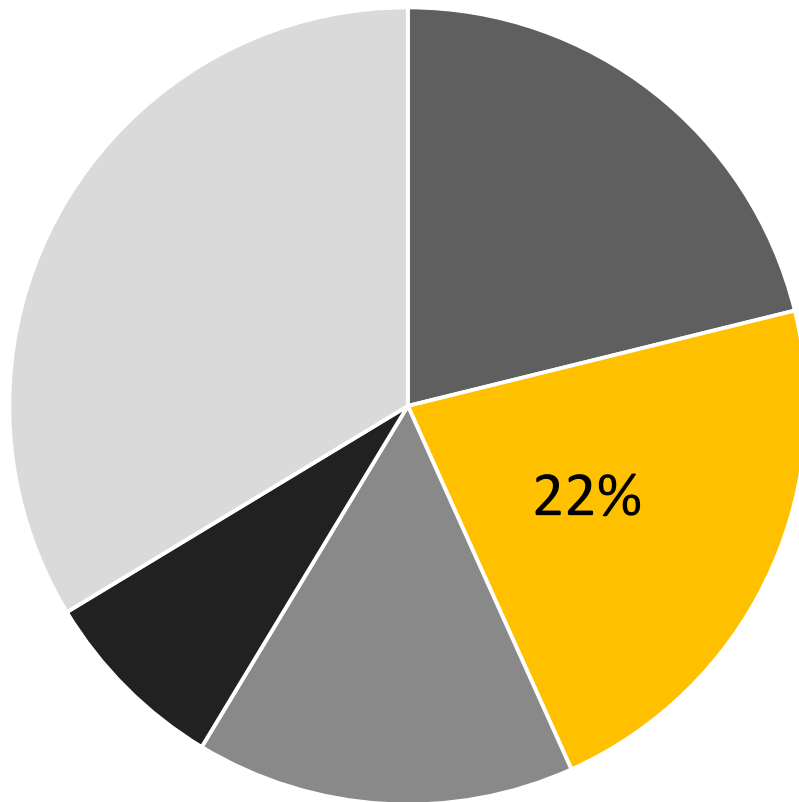
Benchmark's 2025 lithium demand based on battery forecasts



Lithium ion batteries now the driver...

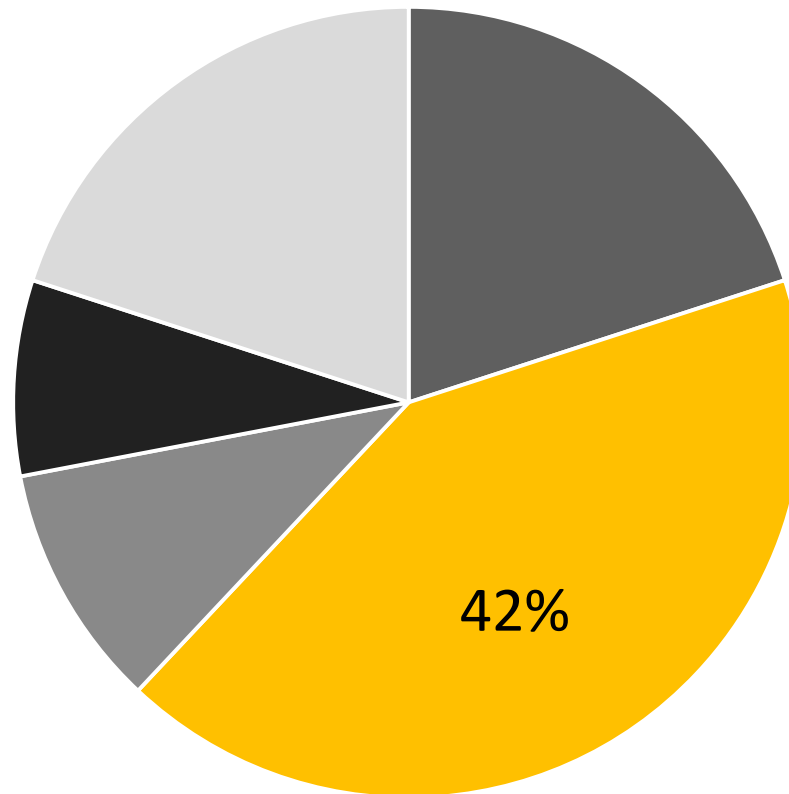
Lithium's End Markets

2006



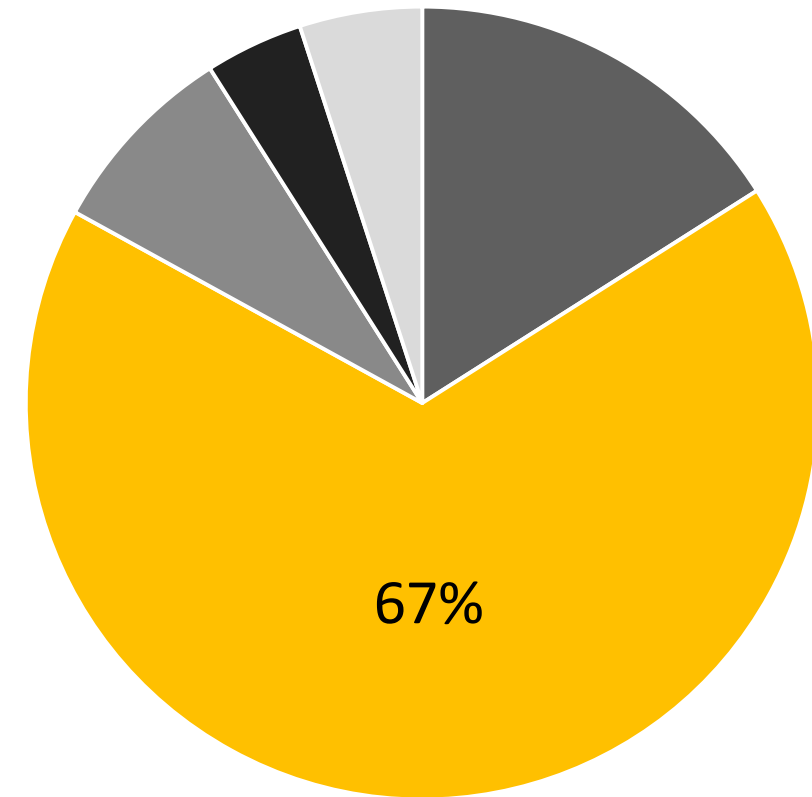
110,000 tonnes

2016



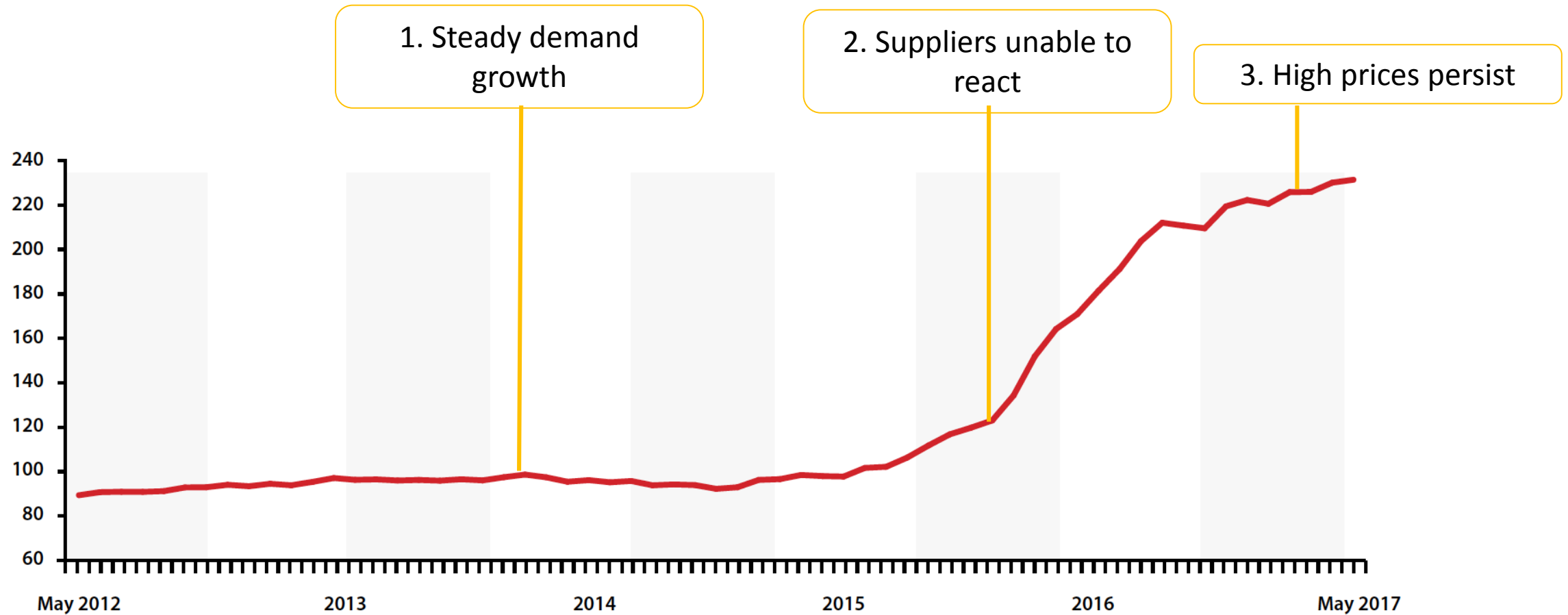
175,000 tonnes

2020

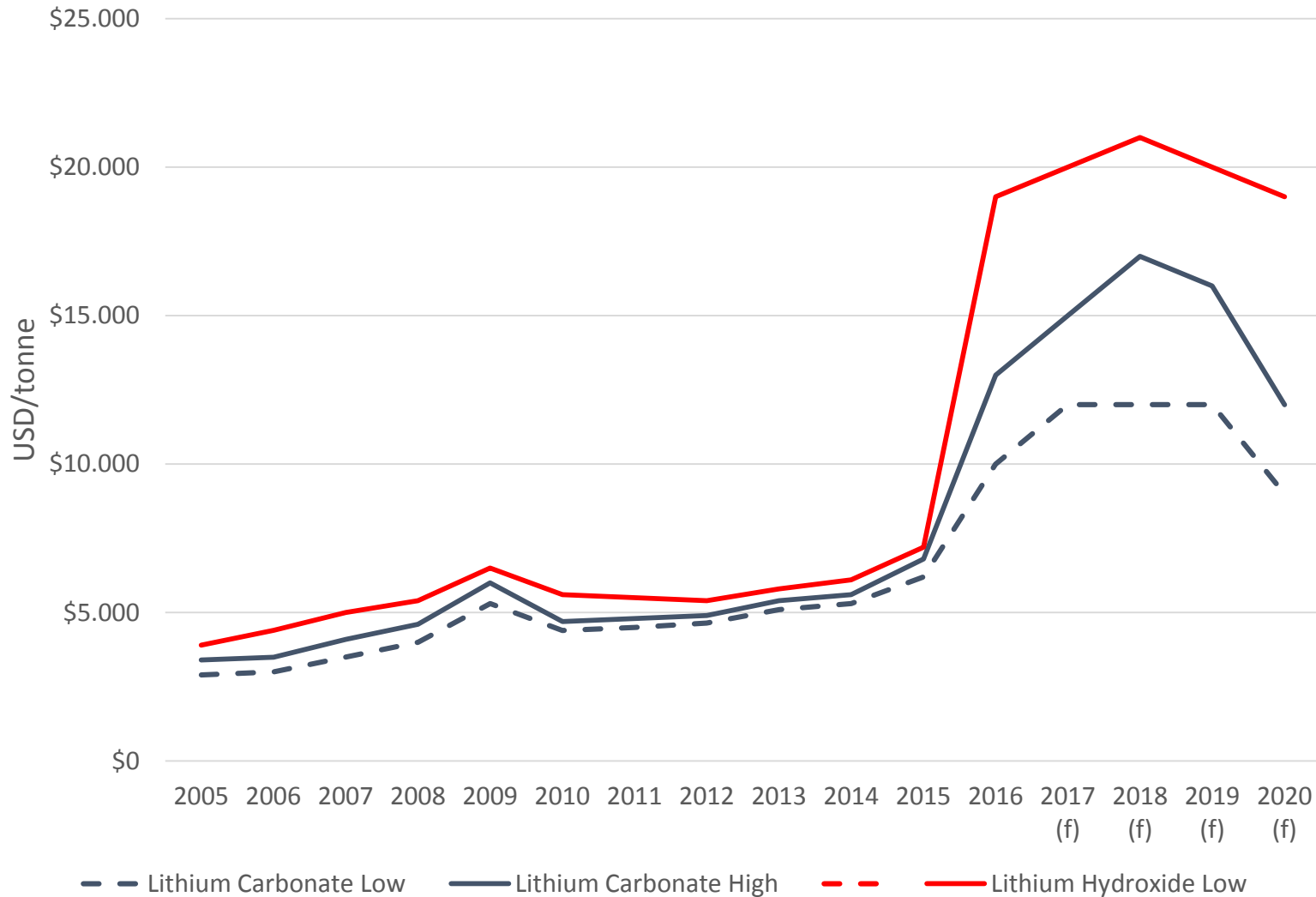


280,000 tonnes

Lithium chemical price trend



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

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

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BENCHMARK MINERAL INTELLIGENCE
Author: Andrew Miller
Analyst: Office: +44 20 1238 1076
and@benchmarkminerals.com

Marketing Director: Simon Meenan

Benchmark Mineral Intelligence
www.benchmarkminerals.com
info@benchmarkminerals.com

Social: @benchmarkminerals
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Lithium

Price surge slows in China, but ROW contracts play catch up

- Lithium majors increase prices for carbonate and hydroxide H2 contracts
- Hydroxide jumps towards \$16/kg while carbonate moves north of \$16/kg
- China's domestic price slow but prices stay high
- BMJ Lithium Price Index up 5.5% in June; 43% YoY
- H2 Lithium ion battery cathode demand outlook strong on e-bus subsidies
- China's EV production up for fourth consecutive month

TERMINOLOGY

Lithium hydroxide: This refers to lithium carbonate, the majority of which is converted into lithium hydroxide for a wider range of end uses including lithium ion batteries.
Lithium carbonate: This refers to any downstream lithium salt that are produced from spodumene hydroxide or lithium ions. For the purposes of this report it refers to the general class of lithium carbonate and hydroxide, any other lithium salt will be specifically stated.
Lithium hydroxide: An important lithium-based compound used in the lithium industry used in a wide range of end-uses including lithium ion battery cathodes, cement, and glass, and pharmaceuticals.
Lithium carbonate: The second largest mineral product in the lithium industry, traditionally used in the production of glass, but also competes with lithium carbonate in the lithium ion cathode sector specifically in chemistry.

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Email: info@benchmarkminerals.com

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Author: Andrew Miller
Analyst: Office: +44 20 1238 1076
and@benchmarkminerals.com

Marketing Director: Simon Meenan
Office: +44 20 1238 1076
sm@benchmarkminerals.com

Benchmark Mineral Intelligence
www.benchmarkminerals.com
info@benchmarkminerals.com

Social: @benchmarkminerals
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Graphite

Price collapse continues as excess supplies prevail

- Four month price lows under further price pressures as Chinese producers re-enter the market
- Benchmark Graphite Index drops a further 6.4%, down 16.3% y-o-y
- Seasonal uptick in Chinese consumption outweighed by falling demand elsewhere
- Further demand side pressures expected in Asia approaching Q2 2016
- Heavy discounts continue as producers attempt to clear stockpiles; High-cost Chinese producers under pressure

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Email: info@benchmarkminerals.com

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sm@benchmarkminerals.com

Marketing Director: Andrew Miller
Office: +44 20 1238 1076
and@benchmarkminerals.com

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www.benchmarkminerals.com
info@benchmarkminerals.com

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Cobalt

Heading here

- Stabilisation of metal prices and reduced volatility leads to dampening of cobalt cathode prices in China, supply still tight
- Chinese expansion in cobalt refining capacity under way in preparation for new raw material supply from Glencore and BMD LDC operations
- Dominex Minerals Benz break ground on \$500 million battery pack facility in Alabama, Gulf Shores
- Benchmark adds 16th lithium ion battery megafactory to its tracker: Dynacore, Fujian, China as 6GBW NMC
- Benchmark estimates Dynacore plant cobalt consumption at 2,000 tonnes annually in the NMC cells

KEY TERMS

Cobalt metal: Cobalt (Co), an element in group 10 of the periodic table, is a transition metal.
Cobalt carbonate: Cobalt carbonate (CoCO₃) is a cobalt compound used in the production of cobalt metal.
Cobalt hydroxide: Cobalt hydroxide (Co(OH)₂) is a cobalt compound used in the production of cobalt metal.
Cobalt sulfate: Cobalt sulfate (CoSO₄) is a cobalt compound used in the production of cobalt metal.
Cobalt chloride: Cobalt chloride (CoCl₂) is a cobalt compound used in the production of cobalt metal.
Cobalt nitrate: Cobalt nitrate (Co(NO₃)₂) is a cobalt compound used in the production of cobalt metal.
Cobalt acetate: Cobalt acetate (Co(CH₃COO)₂) is a cobalt compound used in the production of cobalt metal.
Cobalt oxalate: Cobalt oxalate (CoC₂O₄) is a cobalt compound used in the production of cobalt metal.
Cobalt formate: Cobalt formate (CoHCOO) is a cobalt compound used in the production of cobalt metal.
Cobalt malonate: Cobalt malonate (CoC₃H₂O₄) is a cobalt compound used in the production of cobalt metal.
Cobalt succinate: Cobalt succinate (CoC₄H₄O₄) is a cobalt compound used in the production of cobalt metal.
Cobalt fumarate: Cobalt fumarate (CoC₄H₂O₄) is a cobalt compound used in the production of cobalt metal.
Cobalt maleate: Cobalt maleate (CoC₄H₂O₄) is a cobalt compound used in the production of cobalt metal.
Cobalt crotonate: Cobalt crotonate (CoC₄H₄O₄) is a cobalt compound used in the production of cobalt metal.
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Battery raw material pricing and data

