The Outlook for Electric Vehicles
Selected Themes and Trends
• **Outlook for EV Growth**

• *Implications for the Mining Industry*
**Global EV stock growing rapidly in recent years and passed 3 million milestone in 2017 with China driving growth**

**Evolution of Global EV Stock** BEV and PHEV

![Graph showing the growth of BEV and PHEV stock from 2011 to 2017 with a significant increase in 2016 and 2017.](image)

**Comments**

- Electric car stock almost doubling year-on-year, surpassing 2m vehicle threshold in 2016 and 3m in 2017
- BEV uptake consistently ahead of uptake of PHEVs
- China largest electric car stock with 39% of global total and growing at 136% CAGR. US represents 25% and Europe 23%
- Despite these growth rates, global electric car stock currently represents ~0.2% of total number of passenger light-duty vehicles (PLDVs)
- 3m chargers worldwide (private / workplace) + 320,000 public charges (mostly slow)

*Source: Global EV Outlook 2018; Strategy& analysis*
Global sales of new EVs passed 1 million units in 2017 with China key market and Norway most advanced market

Evolution of Global EV Sales By Country

EV Sales
000s

Source: Global EV Outlook 2018; Strategy& analysis
Forecasts for EV growth range from conservative to bullish

Forecasts for Global EV Fleet Selected

Source: BP; IEA; BNEF; Strategy & analysis
Policy implementation, as well as other factors, will be key to opening up EV markets

Drivers of EV Growth

Public Procurement Schemes
- Buses and municipal vehicles
- Opportunity to demonstrate technology. Bulk orders allows economies of scale

Taxes on CO2 Content
- Policy environment conducive to EV uptake

Fiscal & Related Incentives
- Reduce upfront vehicle purchase
- Complementary measures (preferential parking, emission zone exemptions etc.)

Range Anxiety
- Concerns about EV ranges and access to charge points
- Range improving and charge points increasing

Affordability
- EV selection still limited and expensive compared to some ICE incumbents
- However, battery costs coming down

Examples

- New Energy Vehicle Credit Mandate
- Clean Mobility Package
- National Electric Mobility Mission Plan

Source: Global EV Outlook 2018; Strategy& analysis
**Lithium-ion battery pack prices falling, overall costs of BEVs coming down, which will support adoption rates**

**BNEF 2016 Battery Pack Price Survey Results**

<table>
<thead>
<tr>
<th>Year</th>
<th>$/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1000</td>
</tr>
<tr>
<td>2011</td>
<td>900</td>
</tr>
<tr>
<td>2012</td>
<td>800</td>
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<td>2013</td>
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<td>2015</td>
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<tr>
<td>2016</td>
<td>400</td>
</tr>
<tr>
<td>2017</td>
<td>300</td>
</tr>
<tr>
<td>2025</td>
<td>200</td>
</tr>
<tr>
<td>2030</td>
<td>100</td>
</tr>
</tbody>
</table>

**BEV Cost Breakdown**

- **Battery Costs**
  - 2016: 52%
  - 2020: 64%
  - 2025: 74%
  - 2030: 82%

- **Other Costs**
  - 2016: 48%
  - 2020: 36%
  - 2025: 26%
  - 2030: 18%

Source: Bloomberg New Energy Finance ‘Summit Welcome’ April 2017; IEA
**EV sales will partly be driven by new mobility services such as car sharing, as providers increasingly opt for EVs**

**Comments**

- Growth of car sharing expected to partly drive EV sales. Cars typically well suited for it.
- **Use & range**: As avg. use time is 2-4hrs and 90% of trips are less than 6.2 miles, the EV’s range of typically 70-120 miles is sufficient. Also, there’s limited need for high top speed or performance.
- **Emission**: Many car sharers choose not to own a car for environmental reasons, the EV’s low emission is a clear benefit.
- **Cost**: Reduced fuel costs, lower maintenance costs (simpler powertrain) and possible subsidies make it beneficial.
- Additionally, adoption of EVs in car sharing is expected to increase as OEMs continue to promote the technology.
- For example, Uber (ride hailing) targets a fleet of 100% electric vehicles in 2020, up from approximately 50% (2017).

Source: Navigant Research\(^1\), Strategy& analysis
**IOC**s are making strategic investments in EV technology to prepare for this shift

**Oil & Gas Company Investments in EV Technology** Selected Examples

<table>
<thead>
<tr>
<th>Companies</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="" /></td>
<td>• In 2016 Total acquired Saft battery business for US$1.1bn. In 2018 announced additional investment of US$230m+ in battery technology</td>
</tr>
<tr>
<td><img src="image2.png" alt="" /></td>
<td>• In 2017 Shell bought Dutch-based NewMotion, owner of one of Europe’s largest EV vehicle charging networks. NewMotion will operate in parallel to Shell’s programme of rolling out fast charging points at its forecourts</td>
</tr>
<tr>
<td><img src="image3.png" alt="" /></td>
<td>• In 2018 BP made strategic US$20m investment in StoreDot, Israeli developer of ultra-fast-charging batteries. Technology targeting EV charging in 5 mins.</td>
</tr>
<tr>
<td><img src="image4.png" alt="" /></td>
<td>• In 2018 BP and NIO signed MOU to jointly explore opportunities in advanced mobility in China and internationally</td>
</tr>
<tr>
<td><img src="image5.png" alt="" /></td>
<td>• In 2018 BP invested US$5m in FreeWire, manufacturer of mobile rapid charging systems for EVs. BP to trial technology at selected retail sites in the UK and Europe during 2018</td>
</tr>
<tr>
<td><img src="image6.png" alt="" /></td>
<td>• Saudi Electricity Co signed a deal with Tokyo Electric Power Co and Nissan for first EV pilot project in KSA in 2018</td>
</tr>
</tbody>
</table>

*Source: Press; Strategy& analysis*
• *Outlook for EV Growth*

• *Implications for the Mining Industry*
The positive electric vehicle outlook is creating supply side concerns on key commodities used in EV batteries

“Battery and technology metals among US critical list.” [SP Angel]

“Panasonic plans to develop cobalt-free car batteries” [Reuters]

“Automakers scramble for lithium supply” [SP Angel]

“If shortages for lithium and cobalt are looming large, shortages of graphite are even scarier”. [www.prnewswire.com]

“The motor car industry hasn’t woken up to the fact, I don’t think, how important cobalt is and how ‘tight’ cobalt is” [Ivan Glasenberg]
Current EV battery technology is predicated on the Lithium Ion battery

Battery Pack Facts
- Battery pack included in frame
- Contains many thousands of individual batteries
- Current technologies have battery pack energy density of c. 200 Wh/kg\(^1\)
- Battery packs are up to 100 kWh for light duty vehicles

Note: 1) Global EV Outlook 2018
**Cobalt, Lithium, Graphite and Nickel are major components within all major electric vehicles battery packs**

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Electric vehicles</th>
<th>Anode</th>
<th>Cathode (excl Lithium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCA</td>
<td>Tesla Model 3, Tesla Model S, Tesla Model X</td>
<td>Graphite</td>
<td>Nickel (80%)&lt;br&gt;Cobalt (15%)&lt;br&gt;Aluminium (5%)</td>
</tr>
<tr>
<td>LMO</td>
<td>Nissan Leaf, BMW i3, Chevy Volt</td>
<td>Graphite</td>
<td>Manganese (100%)</td>
</tr>
<tr>
<td>NMC</td>
<td>Nissan Leaf, BMW i3, Chevy Volt</td>
<td>Graphite</td>
<td>Manganese (33%)&lt;br&gt;Cobalt (33%)&lt;br&gt;Nickel (33%)</td>
</tr>
</tbody>
</table>

Lithium, Graphite, Cobalt and Nickel are used within all major electric vehicle battery packs.
**Current technology means there will be benefits to miners with focus on these commodities**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Approx weight per 85 kWh battery</th>
<th>Approx spot cost per lb ($)</th>
<th>Approx cost per battery pack ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium Carbonate</td>
<td>57 kg (126 lb) ¹</td>
<td>8 ⁵</td>
<td>1,005</td>
</tr>
<tr>
<td>Cobalt</td>
<td>20 kg (44 lb) ²</td>
<td>40 ⁵</td>
<td>1,764</td>
</tr>
<tr>
<td>Nickel</td>
<td>100 kg (220 lb) ³</td>
<td>6.5 ⁵</td>
<td>1,433</td>
</tr>
<tr>
<td>Graphite</td>
<td>54 kg (119 lb) ⁴</td>
<td>4.5 *</td>
<td>536</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>4,738</td>
</tr>
</tbody>
</table>

- The weight per battery pack reflects estimates.
- E.g. the 2018 Global Energy Outlook suggests lower usage per kWh of key components. Technological change is constant, particularly in reducing Cobalt content (e.g. 0.13 kg/kWh per Global EV Outlook as compared to 0.22 kg/kWh as per above)

*Estimate of $10,000 / tonne for graphite (Actual pricing data for graphite not readily available)*

2. Calculated based on 0.22kg/KWh – “No cobalt, no Tesla” by Sebastien Gandon, posted on www.techcrunch.com on 1 January 2017
3. Based on the cathode being c.80% Nickel and 15% Cobalt, as per “Breakdown of raw materials in Tesla’s batteries and possible bottlenecks” published on https://electrek.co/ on 1 November 2016
4. Benchmark Mineral Intelligence and 5. SNL mining
Ramping up EV production may create supply constraints on some of the key metals used in lithium ion batteries

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Estimated global production (Tonnes)¹,²</th>
<th>Approx use in 1m 85 kWh EVs (Tonnes)</th>
<th>Percentage of current production</th>
<th>Availability of resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium</td>
<td>43,000</td>
<td>10,800</td>
<td>25%</td>
<td>❌</td>
</tr>
<tr>
<td>Cobalt</td>
<td>115,000</td>
<td>20,000</td>
<td>17%*</td>
<td>❌</td>
</tr>
<tr>
<td>Nickel</td>
<td>1,986,000</td>
<td>100,000</td>
<td>5%</td>
<td>❌</td>
</tr>
</tbody>
</table>

• The copper content of EVs also expected to be significantly higher (c.83kg) than for current internal combustion engine based vehicles (c.23kg)³.

• Given relative abundance of copper, overall effect more limited.

• In scenario of 125m vehicles by 2030, annual battery capacity being added to EVs by 2030 is 775 GWh⁴.

* Using Global EV Outlook estimate of 0.13 kg / kWh of Cobalt, percentage of current production for Cobalt reduces to 10%.

1. Lithium production reflects 2017 estimates (excl USA) per the January 2018 U.S. Geological Survey
2. Cobalt and Nickel production reflect 2016 estimates as per SNL
3. 2017.06-E-Mobility-Factsheet-1
4. Global EV Outlook 2018
We have already seen the electric vehicle impact on Lithium and Cobalt pricing in recent years

Source: SNL mining
**Uncertainty on EV uptake, timing and technology means responses across the mining industry varies**

<table>
<thead>
<tr>
<th>Portfolios of majors</th>
<th>Varies by major as portfolio mixes differ</th>
</tr>
</thead>
</table>
| Investment           | Some targeted acquisitions made in recent years  
                        | Overall mining capital expenditure still cautious following recent challenges facing industry |
| Pricing              | Cobalt and Lithium have volatile price curves  
                        | Demand highly dependent on EV uptake and technology |
| Timing of mass EV production | Still some uncertainty around mass uptake of EVs  
                        | Wide ranging scenarios – heavily policy dependant |
| Alternative technology | Focus on reducing need for Cobalt in existing battery technology  
                        | Hydrogen fuel cells |
Thank You

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