Sunrise Battery Materials Complex

Building a sustainable supply chain for electric vehicles

BMO Metals & Mining Conference
February 2020
Cautionary statement

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Streamlined Life Cycle Analysis by Energetics, Feb 2020. The GHG emission intensities of alternative processing routes are based on literature data that cannot be effectively harmonized. For comparison purposes the only harmonization that has occurred has been on end product (NiSO4) and using economic allocation to end products. Any comparison against Sunrise should be considered indicative only.
Decarbonisation – the industrial challenge of this century

Metals are the new oil – for electrical generation, storage, distribution and light-weighting

To scale - area represents global market value of the commodity

Oil
Reinventing the supply chain

Raw materials are the most vulnerable part of the EV supply chain

Supply Chain Foundations

1. Secure
   - Geology
   - Geography

2. Low cost
   - Chemistry
   - Metal prices

3. Sustainable
   - Brand / reputation
   - Life cycle assessment
Supply Chain Foundations

1. Secure
   - Geology
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Ore reserves and production rates

Metal markets area function of geological scarcity and demand

Implied 30-Year Reserve Life as Multiple of Current Production

Raw material demand in kilo tonnes per annum, base case

Cobalt
- 2018: 128
- 2030: 274

Lithium (LCE)
- 2018: 229
- 2030: 1,469

Nickel
- 2018: 2,171
- 2030: 3,302

Manganese
- 2018: 19,100
- 2030: 22,600

Source: Global Battery Alliance, WEF; McKinsey analysis

1 Demand for class 1 nickel for batteries

Source: USGS; Bernstein
Reserve depletion rates

Projected EV stock by 2050 will have a huge impact on ore reserve depletion rates

"Every project that has a name – we still don’t have enough. These are growth rates the mining industry has never seen before. The scale of the challenge hasn’t really set in for people in the industry. The balance sheets of miners aren’t strong enough to support this level of growth."

- Benchmark Minerals, Feb 2020

Source: USGS, SNL Financial, CRU, Wood Mackenzie, and Bernstein estimates (2050) and analysis
Development timeframes

Building new nickel / cobalt capacity takes time

“...these are markets that really need consistent investment – mines don’t build themselves. You can’t turn on that supply in 1 to 2 years. The price levels we’re seeing now aren’t enough to incentivise that.”

– Benchmark Minerals, Feb 2020

Source: SNL and public data
Battery materials are geographically concentrated

Concentration increases supply risk

**Cobalt**
- Mine supply: DRC 72%
- Refined Production: China 65%

**Nickel**
- Mine supply: Indo/Phil 39%, Russia 12%
- Refined Production: China 29%, Russia 23%

**Lithium**
- Mine supply: Australia 62%, Chile 18%
- Refined Production: China 54%, Chile 37%

Source: USGS and internal analysis. Refined production refers to cobalt chemical production, Class 1 nickel and Li2CO3 and LiOH production.
Supply Chain Foundations

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Battery pack costs are declining rapidly…

Cost parity with ICEs is approaching fast

<table>
<thead>
<tr>
<th>MINING</th>
<th>REFINING</th>
<th>ACTIVE MATERIALS</th>
<th>CELLS</th>
<th>PACKS</th>
<th>USE AND SERVICE</th>
<th>RECYCLE / REUSE</th>
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**CELL PRODUCTION**

~$100/kWh

**PACK ASSEMBLY**

~$50/kWh

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<th>2010 PACK PRICE</th>
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<td>~$1,000/kWh</td>
<td>~$150/kWh</td>
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Learning Rate of ~20% pa

Source: Internal company analysis validated against various studies (GREET; ANL BatPac Model; Avicenne; BNEF; Bernstein). Note: $/kWh figures are calculated at pack level, not cell level and are not inclusive of corporate overheads, R&D expenses and margins.
… but the benefits from economies of scale will diminish

Forecasting ICE-parity by middle of this decade

The largest contributing factors to battery pack unit cost reductions have been:

- Economies of scale in production
- Increased energy density (chemistry)

Economies of scale will taper over coming years

Chemistry and materials science remain large areas of improvement

Source: SNE Research, and Bernstein estimates and analysis (Global Energy Storage & Electric Vehicles team)
Cathode chemistry has trade-offs

Cobalt thrifting – a case study in shifting risk

Benefits in chemistry, however, come with other trade-offs:
- Life cycle and safety
- Higher cost production materials and processes

By thrifting cobalt (NMC111 to NMC811) you shift pricing risk to nickel

In both NMC111 and NMC811, nickel and cobalt make up 75% of total metal cost in active material (thrifting does no more than shift risk between metals)

Note: Excludes manganese, which is immaterial for the analysis. Assumes long-term market consensus metal prices as at 6 Feb 2020.
Metal price volatility - a significant risk

Unless OEMs manage metal price volatility, cost competitiveness is rapidly eroded

LME Nickel Price
Real 2020 USD/tonne

High: $75,307
15Y Avg: $17,639
Low: $8,106
@ 4 Feb 2020: $12,640

Nickel (and cobalt) prices exhibit high volatility for extended periods

Cell Cost Breakdown ($/kWh)
(NMC811)

Price Scenarios | Cost of Ni + Co
---|---
1. Spot ($15k/t Ni, $39k/t Co) | $13.00 / kWh
2. Consensus ($18.5k/t Ni, $50k/t Co) (+25%) | $16.30 / kWh
3. High Ni ($30k/t Ni, $50k/t Co) (+85%) | $24.00 / kWh
4. High Ni & Co ($30k/t Ni, $77k/t Co) (+102%) | $26.20 / kWh

For an OEM producing 1 million EVs per annum with a 50kWh battery pack, Ni / Co price volatility erodes up to $660M pa of value between scenarios 1 and 4

Source: LME. Cell cost breakdowns based on internal company analysis.
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New supply chains create brand and reputation risk

Moral hazard: should these risks be contracted out to third party agents?

Brand, Reputation & ESG

- Child labour and slavery
- Water depletion or contamination
- Carbon footprint
- Submarine tailings disposal
- Deforestation
- Extra-territorial law suits
EVs must be designed around the battery if they are to deliver benefits to society.

Raw materials (mining and processing) in the battery leave the biggest CO2 footprint on the supply chain.

OEMs need measurable carbon data to benchmark performance.

Nickel and cobalt are the major contributors to an EV's carbon footprint, which varies widely depending on the source of metal and the processing route.

Source: Volkswagen
Nickel and cobalt – why they are so important

The carbon footprint of the battery pack is determined by mining/refining process routes….

MINING

REFINING

ACTIVE MATERIALS

CELLS

PACKS

TOTAL

40 -139

kgCO2e/kWh

21

kgCO2e/kWh

20

kgCO2e/kWh

2

kgCO2e/kWh

84 - 183

kgCO2e/kWh

4.1 – 8.8 t

CO2e per vehicle

Source: Energetics report and internal company analysis (GREET; ANL BatPac Model; Avicenne; Bernstein), modified to reflect the kg CO2e per kWh of pack capacity utilizing NMC 811 cathode chemistry. Mining and Refining, assumes nickel and cobalt is refined through to nickel and cobalt sulfate for conversion to precursor. Electrical energy mix assumes FeNi and NPI production is in China, HPAL in Indonesia (using black coal) and NiS is in Australia. Note that the technology for conversion of FeNi or NPI to battery-grade sulfate has not been proven at industrial scale, may not be economically viable and may add further GHG emissions which have not been accounted for in this study. Total CO2e production per vehicle assumes a 50kWh battery pack.
Strategic procurement matters

... where nickel and cobalt make up between one-quarter and two-thirds of total pack emissions

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Source: See note on previous page. Sunrise range based on 100% renewable power supply versus Australian grid energy mix. Note that while a theoretical process was developed and evaluated to convert FeNi and NPI to battery grade sulfate, an industrial scale process has yet to be proven.
Sunrise Integrated Battery Complex

A template for industry-leading emissions and cost performance across the cathode supply chain
Large, low cost, long-life (and in Australia)
The focus is battery chemicals (metal salts and beyond)
Sunrise – a breakdown of CO2e hotspots

Integrating renewable power at Sunrise reduces carbon by circa 30%

Option to eliminate one-third of Scope 2 emissions by moving to a renewable PPA or connecting to adjacent solar capacity

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<th>Indicator</th>
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<td>Sunrise (Imported Power)</td>
<td></td>
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<tr>
<td>Per kg Ni metal produced</td>
<td>kg CO2 e/kg</td>
<td>17.2</td>
</tr>
<tr>
<td>Per kg Co metal produced</td>
<td>kg CO2 e/kg</td>
<td>45.4</td>
</tr>
<tr>
<td>Per kg Sc metal produced</td>
<td>kg CO2 e/kg</td>
<td>2,107</td>
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| Sunrise (Renewable Power)        |             |       |
| Per kg Ni metal produced         | kg CO2 e/kg | 10.8  |
| Per kg Co metal produced         | kg CO2 e/kg | 28.4  |
| Per kg Sc metal produced         | kg CO2 e/kg | 1,318 |

The vision for Sunrise and Central NSW

Integrated precursor / cathode production, renewable generation and recycling

Renewable Power: The Central-West Renewable Energy Zone (REZ) will add 3GW of new solar generation capacity to Sunrise’s doorstep

Linking Li – Ni - Co: The east-west national rail corridor connects at Parkes, linking Sunrise to the world’s largest sources of lithium production

Active material production: significant cost savings can be generated by co-locating Ni/Co sulfate and precursor/cathode production

Closed recycling loop: Surplus autoclave and refining capacity allows cost-effective recycling of used cathode to recover metals (Parkes Special Activation Precinct is a dedicated industrial zone incorporating recycling/re-use facilities powered by waste-to-energy).
Clean TeQ Holdings Limited
12/21 Howleys Rd
Notting Hill VIC 3168
Australia

www.cleanteq.com
A focus on nickel in electric vehicle batteries

Understanding cost and the carbon footprint

BMO Metals & Mining, February 2020
Sam Riggall, CEO
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Decarbonisation – the industrial challenge of this century

Metals are the new oil – for electrical generation, storage, distribution and light-weighting

To scale - area represents global market value of the commodity
Nickel - mind the gap

Where will battery-grade nickel come from?

Nickel Market Balance 2018-2030 (kt Ni pa)

- 2,200 2018 Ni Demand
- 110 Stainless Steel Growth
- 520 Mostly Class 2 Ni
- 25 2030 Ni Demand
- 330 Mine Closures
- 270 Other Batteries Growth
- 915 Brownfield Expansions
- 2,200 New Mine Development
- 2,200 2018 Ni Supply

Implies 6% pa CAGR in Class 1 Nickel compared to 0.5% pa average over the past 20 years

Source: Internal analysis assuming 1.5% pa global passenger vehicle growth and a 15% EV penetration rate by 2030. Battery chemistry demand by 2030 is 90% split between NCM622 / NCM811 / NCA and 10% LFP. Average battery pack size is 50kWh. Stainless growth is 1% per year, Alloys / Plating growth is 1.5% per year. Mine closure and expansion data from Wood Mackenzie nickel market forecasts, September 2019. Forecast for PAL investment assumes industry standard capital intensity for 520ktpa of incremental LME Class 1 growth from laterite ore.
Nickel - ore styles and ore genesis

The economics of laterite and sulfide development rely on very different considerations, but…. 

**Laterite ore**
- Red Laterite (Oxyhydroxide)
- Yellow Laterite (Limonite)
- Saprolite zone

**Sulfide ore**
- Pyrrhotite $>>$
- Magnetite $>>$
- << Pentlandite

<table>
<thead>
<tr>
<th></th>
<th>Grade</th>
<th>Acid</th>
<th>By-products</th>
<th>Energy</th>
<th>Cost</th>
<th>Scarcity</th>
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<tr>
<td><strong>Pyromet (RKEF):</strong></td>
<td>FeNi, NPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Hydromet (PAL):</strong></td>
<td>MSP, MHP, sulfate eluate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pyromet (smelt+refine):</strong></td>
<td>Matte, LME metal (powder, briquette, cathode, etc)</td>
<td></td>
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</table>
Good nickel sulfide resources are geologically scarce

...laterites will need to do most of the heavy lifting to meet stainless and EV demand

- The world is increasingly dependent on nickel laterite ores
- Nickel sulfide resources are geologically scarce and insufficient to support forecast EV growth
- Pyrometallurgical processing of laterite ore will service stainless steel markets (NPI / FeNi)
- Hydrometallurgical processing of laterite ore (pressure acid leach, or PAL) will service battery markets

Source: CRU Nickel & Cobalt Market Study, October 2018
Feedstocks – many routes to nickel (and cobalt) sulfate

Cost and complexity are a function of impurity loads in the feedstock

- **Nickel Pig Iron** (Class 2)  
  8 - 16% Ni

- **FerroNickel** (Class 2)  
  20 - 25% Ni

- **MHP** (Intermediate)  
  ~40% Ni / 1.5% Co

- **MSP** (Intermediate)  
  ~60% Ni / 4.0% Co

- **Matte** (Intermediate)  
  ~75% Ni / 1.5% Co

- **Sunrise Eluate** (Intermediate)  
  70% Ni / 18% Co

- **LME Ni** (Class 1)  
  99.8% Ni

- **Sunrise NiSO₄·6H₂O** (LiB High Purity)  
  99.94% Ni
Can FeNi and NPI plug the gap?

Impurities increase conversion costs to nickel / cobalt sulfate

1.5 tonne of LME-grade nickel contains ~3.0kg of impurities, of which ~2.1kg needs to be removed to produce battery-grade nickel sulfate.

Assumes laterite grading 1.5% Ni and 0.075% Co. Nickel equivalent grade calculated using a US$7.5/lb Ni price and a US$22.5/lb Co price. cRIP eluate impurities include all compounds other than payable nickel, cobalt and sulphate mass. LME Nickel and LiB grade NiSO4.6H2O use nickel grade only, not nickel equivalent (hence a reduction in payable metal).
Carbon – a life cycle analysis of CO2 intensity

EVs must be designed around the battery if they are to deliver benefits to society

Hot spots in the production process of the Volkswagen ID.3
The battery causes over 40 percent of CO₂ emissions

Risk, but also the largest opportunity

[Diagram showing CO₂ emissions percentages in different materials and components]

Source: Volkswagen (preliminary calculation)

Raw materials (mining and processing) in the battery leave the biggest CO₂ footprint on the supply chain

OEMs need measurable carbon data to benchmark performance

Nickel and cobalt are the major contributors to an EV’s carbon footprint, which varies widely depending on the source of metal and the processing route

Source: Volkswagen
Carbon accounting for the battery supply chain

The carbon footprint of the battery pack is determined largely by mining/refining process routes. 

**MINING**

**REFINING**

**ACTIVE MATERIALS**

**CELLS**

**PACKS**

**TOTAL**

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Importance of nickel and cobalt

... where nickel and cobalt make up between one-quarter and two-thirds of total pack emissions

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Nickel sulfate process routes

The environmental promise of EVs depends greatly on procurement strategy

Source: See note on previous page. Sunrise emissions based on renewable electricity supply.

Source: See note on previous page. Sunrise emissions based on renewable electricity supply.
Sunrise Integrated Battery Complex

A template for industry-leading emissions and cost performance across the cathode supply chain
Sunrise Battery Materials Complex
Sunrise Battery Materials Complex

Cobalt Sulphate
Scandium Oxide
Nickel Sulphate
## GHG intensity of Clean TeQ Sunrise

### Understanding the Sunrise emission hot spots

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<th>Indicator</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sunrise Project, cradle to gate</td>
<td>t CO₂e/year</td>
<td>571,457</td>
</tr>
<tr>
<td>- scope 1 emissions</td>
<td>t CO₂e/year</td>
<td>265,577</td>
</tr>
<tr>
<td>- scope 2 emissions</td>
<td>t CO₂e/year</td>
<td>165,844</td>
</tr>
<tr>
<td>- scope 3 emissions</td>
<td>t CO₂e/year</td>
<td>140,036</td>
</tr>
<tr>
<td>Nickel carbon intensity</td>
<td>kg CO₂e/kg Ni</td>
<td>17.2</td>
</tr>
<tr>
<td>Cobalt carbon intensity</td>
<td>kg CO₂e/kg Co</td>
<td>45.4</td>
</tr>
<tr>
<td>Scandium carbon intensity</td>
<td>kg CO₂e/kg Sc</td>
<td>2,107</td>
</tr>
</tbody>
</table>

Source: Energetics Report and internal company analysis. Assumes Australian grid energy mix in carbon calculation (scope 2).
Breakdown of CO2e releases for Sunrise

Integrating renewable power at Sunrise reduces carbon by circa 30%


<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunrise (Imported Power)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per kg Ni metal produced</td>
<td>kg CO2 e/kg</td>
<td>17.2</td>
</tr>
<tr>
<td>Per kg Co metal produced</td>
<td>kg CO2 e/kg</td>
<td>45.4</td>
</tr>
<tr>
<td>Per kg Sc metal produced</td>
<td>kg CO2 e/kg</td>
<td>2,107</td>
</tr>
<tr>
<td>Sunrise (Renewable Power)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per kg Ni metal produced</td>
<td>kg CO2 e/kg</td>
<td>10.8</td>
</tr>
<tr>
<td>Per kg Co metal produced</td>
<td>kg CO2 e/kg</td>
<td>28.4</td>
</tr>
<tr>
<td>Per kg Sc metal produced</td>
<td>kg CO2 e/kg</td>
<td>1,318</td>
</tr>
</tbody>
</table>

Option to eliminate one-third of emissions by moving to a renewable PPA or connecting to adjacent solar capacity.
The vision for Sunrise and Central NSW

Integrated precursor / cathode production, renewable generation and recycling

Renewable Power: The Central-West Renewable Energy Zone (REZ) will add 3GW of new solar generation capacity to Sunrise’s doorstep

Linking Li – Ni - Co: The east-west national rail corridor connects at Parkes, linking Sunrise to the world’s largest sources of lithium production

Active material production: significant cost savings can be generated by co-locating Ni/Co sulfate and precursor/cathode production

Closed recycling loop: Surplus autoclave and refining capacity allows cost-effective recycling of used cathode to recover metals (Parkes Special Activation Precinct is a dedicated industrial zone incorporating recycling/re-use facilities powered by waste-to-energy).