Supply Chain of Raw Materials Used in the Manufacturing of Light-Duty Vehicle Li-ion Batteries

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Introduction

➢ First attempt to include raw materials in the Benchmark Report

➢ The raw materials analysis is intended to capture the flow of raw material from mine to refinery to battery component manufacturing facility.
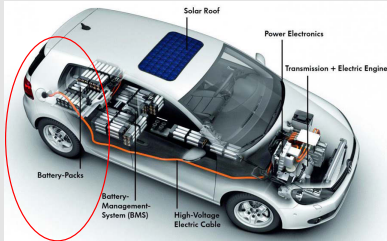
Figure 1. Electric vehicle
Source: http://www.alternative-energy-news.info/technology/transportation/electric-cars/

➢ As a start, this analysis looks at the raw materials used to manufacture cathode sheets for light-duty vehicle (LDV) batteries.

Key Materials Used in LDV Batteries

➢ Critical materials include lithium, graphite, cobalt, and manganese

➢ These materials are finite resources, and their production is highly concentrated in a few economies.
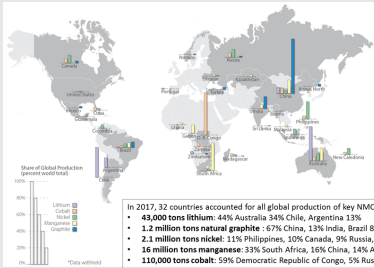
In 2017, 32 countries accounted for all global production of key NMC materials
• **43,000 tons lithium:** 44% Australia 34% Chile, Argentina 13%
• **1.2 million tons natural graphite :** 67% China, 13% India, Brazil 8%
• **2.1 million tons nickel:** 11% Philippines, 10% Canada, 9% Russia, 9% Australia
• **16 million tons manganese:** 33% South Africa, 16% China, 14% Australia
• **110,000 tons cobalt:** 59% Democratic Republic of Congo, 5% Russia, 5% Australia

Figure 2. Key materials locations
Source: Steward et al. 2018

➢ As electric vehicle deployments increase, LIB production for vehicles is becoming an increasingly important source of demand.

Years	Total LDV	Units	Material Consumption				
			Cobalt	Lithium	Nickel	Manganese	Graphite
2014		metric tons	1,691	1,381	4,558	1,595	10,649
	(9,600 MWh)	% of mine production	1.40%	4.40%	0.20%	0.00%	
2015		metric tons	3,593	2,935	9,685	3,390	22,630
	(20,400 MWh)	% of mine production	2.90%	9.30%	0.40%	0.00%	
2016		metric tons	5,505	4,497	14,841	5,195	34,677
	(31,260 MWh)	% of mine production	5.00%	11.80%	0.70%	0.00%	

Table 1. LDV materials use estimates (2014–2016)
Source: NREL 2018

➢ This analysis is focused on cobalt and lithium markets.

Conclusion

➢ The analysis serves as a foundation for incorporating the raw materials link for other clean energy technologies into future benchmark reports.

➢ Disaggregating data to track supply chain of raw materials used by a specific technology remains a challenge.

Production

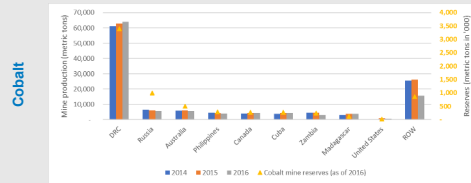➢ Cobalt is used to produce cathode sheet for LIB cells.

Figure 3. Cobalt reserves and mines production, 2014–2016. Source: USGS, 2018
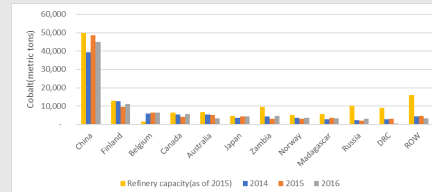
Figure 4. Cobalt refinery production and capacity. Source: USGS 2018; NREL estimates.

➢ Lithium is used to produce cathode sheets as well as electrolyte components of LIB cells.

➢ The supply chain includes mining (from brine/spodumene), and beneficiation and refining into lithium carbonate and hydroxide.
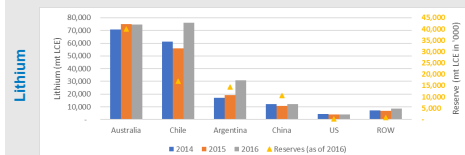
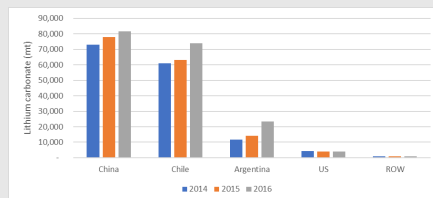**Figure 5. Lithium reserves and mine production. Source: USGS and Cobalt Institute 2018**

Figure 6. Lithium carbonate production. Source: IHS Markit 2018

Demand

➢ Estimated demand for cobalt – all uses:

- Li-ion batteries (other uses) 35%
- Li-ion batteries (LDV) 5%
- Superalloys 20%
- Hardmetals 8%
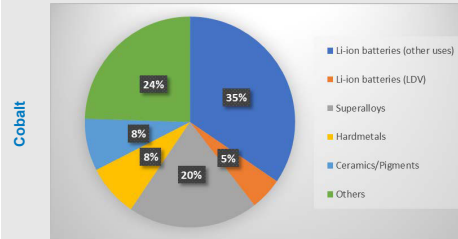- Ceramics/Pigments 8%
- Others 24%

Figure 7. Global consumption of cobalt for all uses in 2016 (110,100 metric tons)
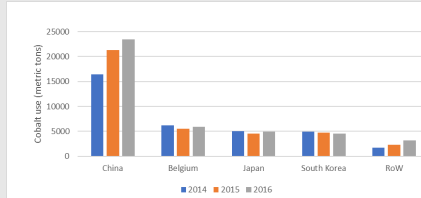Source: NREL

➢ Estimated demand for cobalt – LDV batteries:

Figure 8. Cobalt demand to manufacture cathode active materials for LDV LIB cells.
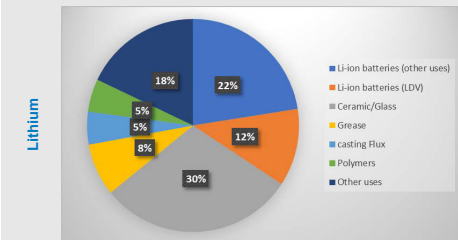Source: NREL

➢ Estimated demand for lithium – all uses:

- Li-ion batteries (other uses) 22%
- Li-ion batteries (LDV) 12%
- Ceramic/Glass 30%
- Grease 8%
- casting Flux 5%
- Polymers 5%
- Other uses 18%

Figure 9. Global consumption of lithium in 2016 (199,479 metric tons LCE). Source: NREL
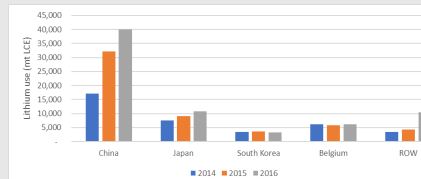
➢ Estimated demand of lithium for LDV batteries:

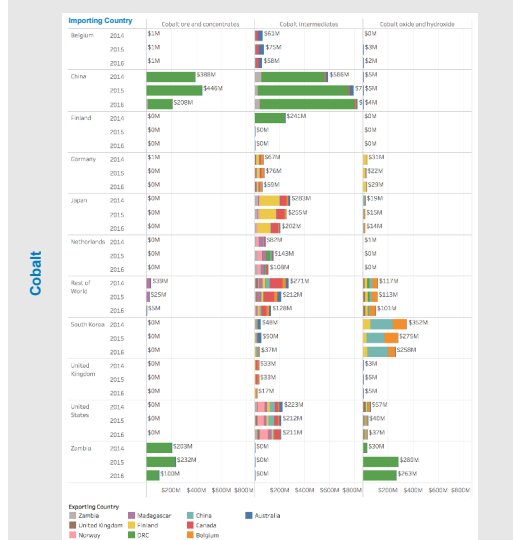**Figure 10. Lithium use for LDV Li-ion battery materials. Source: NREL**

Trade

Figure 11. Import and export of cobalt materials to trading partners 2014–2016 (in 2014 US$). Note: Cobalt ores and concentrates (HS-260500), cobalt oxides, and hydroxides; commercial cobalt oxides (HS – 282200) and cobalt mattes, and other intermediate products of cobalt metallurgy; unwrought cobalt; and powders (HS – 810520).
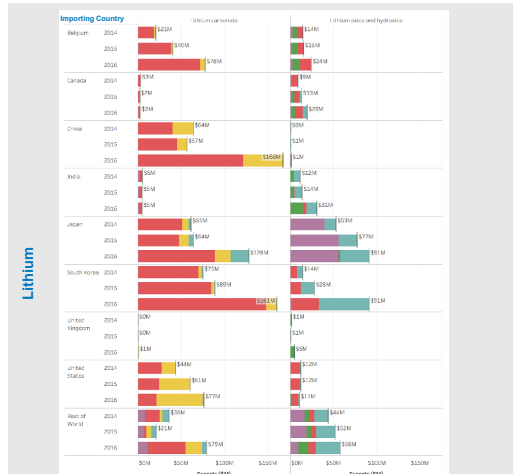
Figure 12. Imports and exports of lithium materials: lithium carbonate (HS – 283691) and lithium oxide and hydroxide (HS – 282520).

CEMAC Clean Energy Manufacturing Analysis Center
Operated by the Joint Institute for Strategic Energy Analysis

JISEA Joint Institute for Strategic Energy Analysis