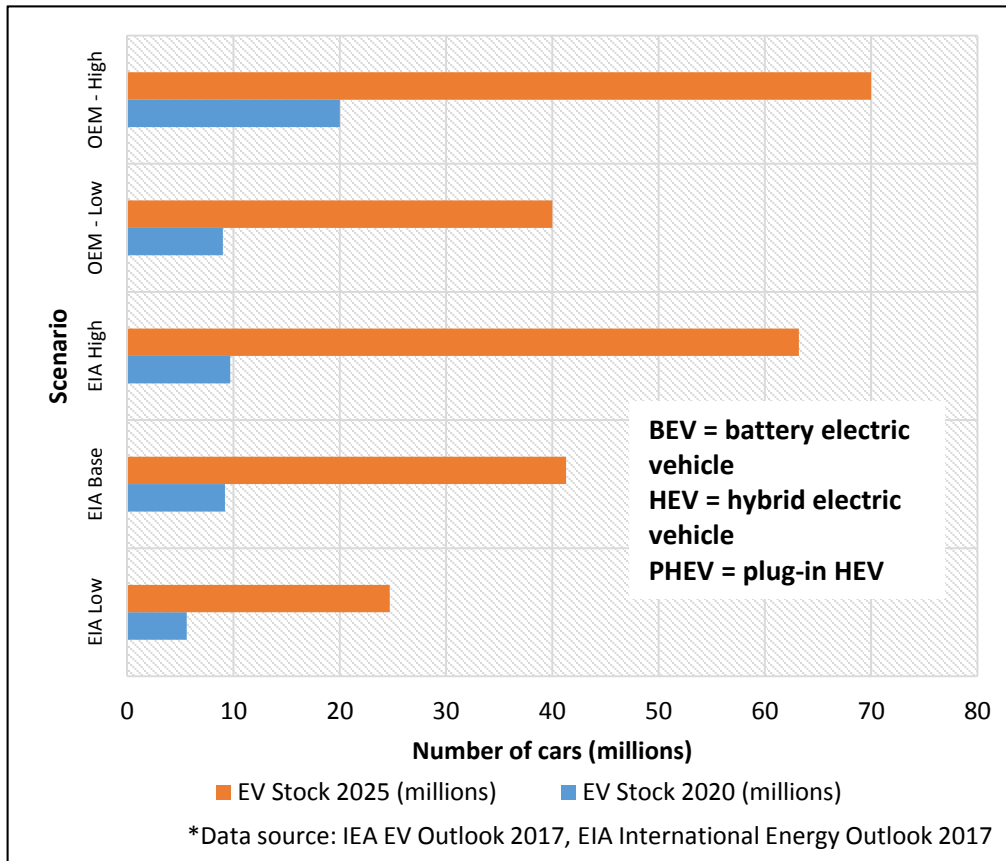


Eyes are on Cobalt

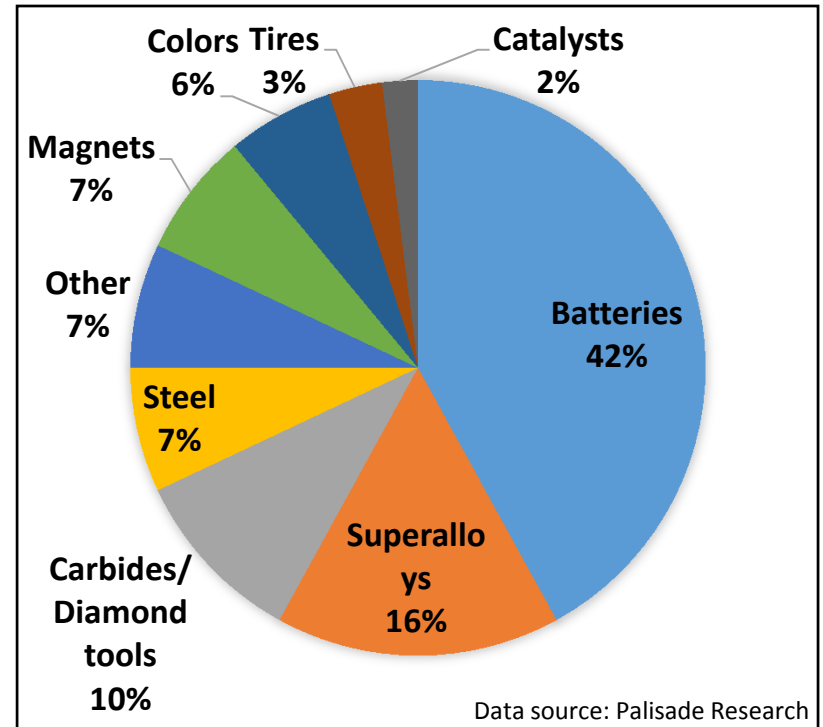
Co demand will grow with lithium ion battery demand



- A 200-mile range **BEV consumes 9-26 kg cobalt** and a **PHEV consumes 3-9 kg of cobalt**, depending on lithium ion battery chemistry and size.

* See appendix for scenario definition and assumptions

* OEM – original equipment manufacturer – EV manufacturers

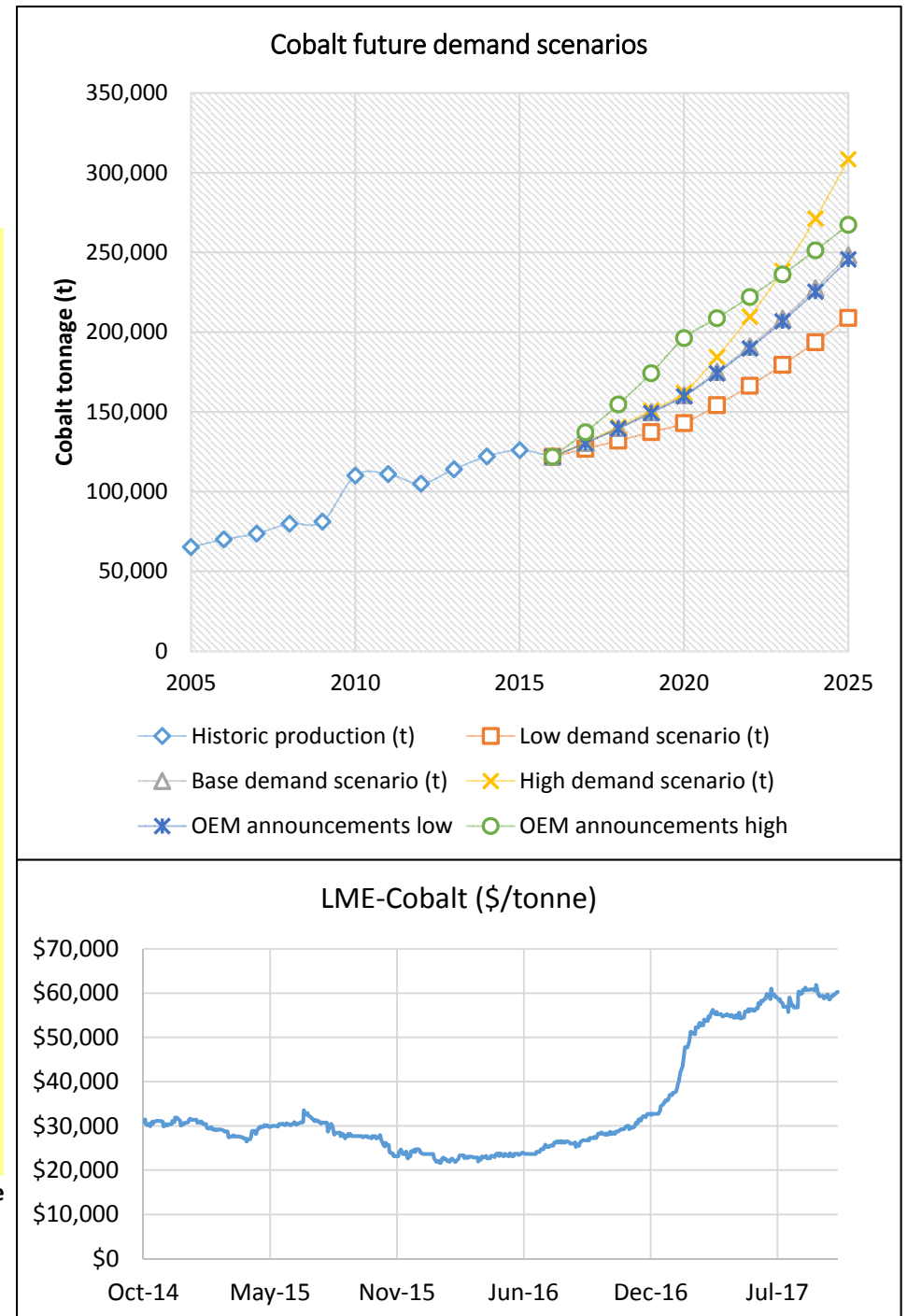


- Consuming more than 42% of the world's total cobalt production, the **battery industry is by far the largest demand driver for cobalt.**
- **Consumer electronics drives almost 90% of battery demand**, followed by electric vehicles and stationary energy storage systems.
- In the future, **electric vehicles will drive cobalt demand** as this potentially large battery using industry grows in volume.
- Nickel sulfide batteries form only 3% of the battery market, making **lithium ion batteries** the majority share of the battery market.
- Batteries use **cobalt sulfate** as raw material.

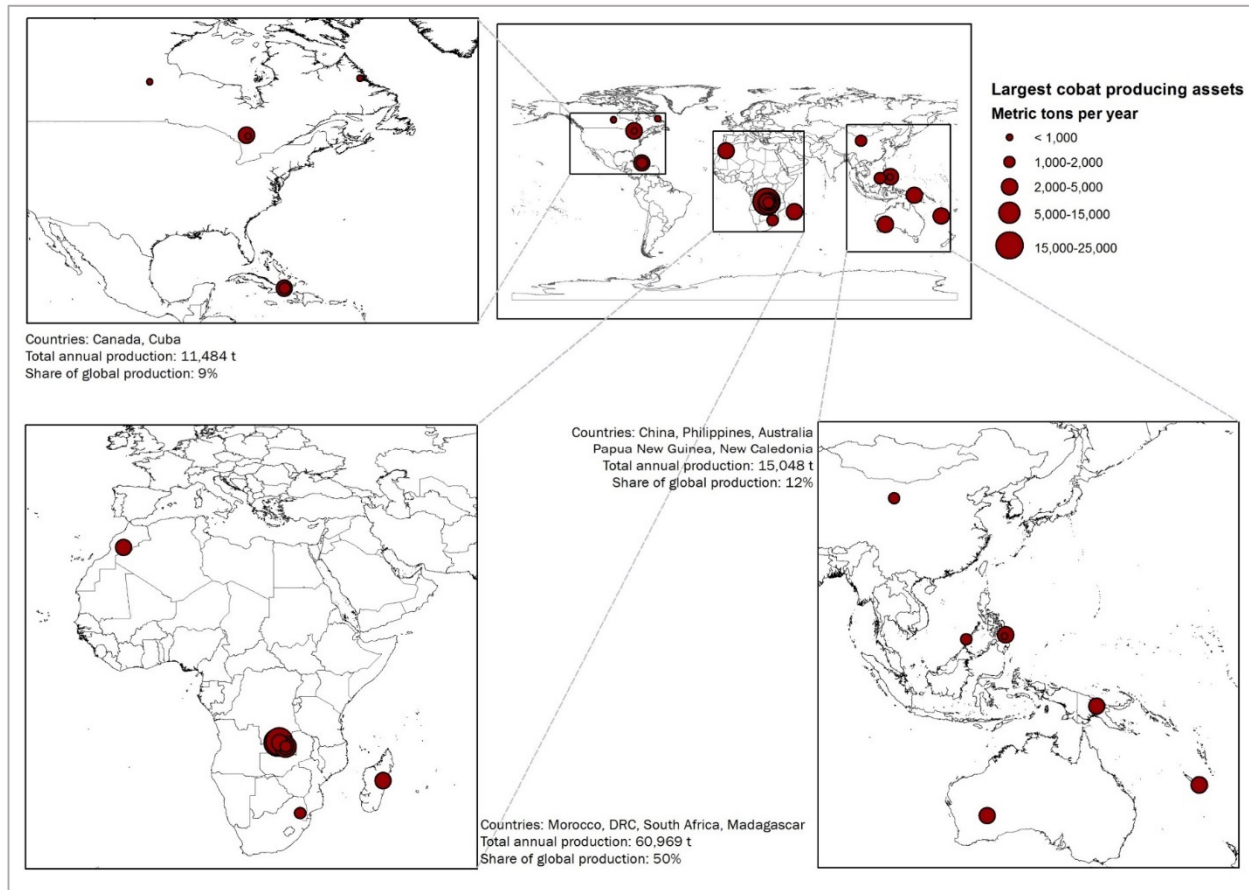
Cobalt supply will need to grow at unprecedented levels to match demand

- Annual cobalt mine production in the years 2010-16 has been the highest for all recorded years.
- The future demand is expected to drive a significant ramp up in production.
- Demand scenarios at right show include cobalt demand from all battery and non-battery markets.
- The low, base, and high demand scenarios are based on EIA's EV outlook 2017, and OEM low and high scenarios are based on IEA's global EV outlook 2017.
- All scenarios differ in EV deployment numbers, but assumptions for other markets are uniform (see appendix for assumptions).
- The **EIA low scenario shows a 4% CAGR from 2016-20 and 7.9% CAGR from 2020-25.**
- The **EIA high scenario shows a 7.4% CAGR from 2016-20 and 13.7% from 2020-25.**
- The **OEM high scenario shows a 12.6% CAGR from 2016-20 and 6.4% from 2020-25.**
- **Actual average CAGR in cobalt production was 6.4% between 2005-16.**
- **Cobalt price has increased over 84% since Jan 2017, and 152% since Jan 2016.**

*Data source: CEE/BEG, IEA EV Outlook 2017, Argonne BatPAC model, London Metal Exchange (LME)



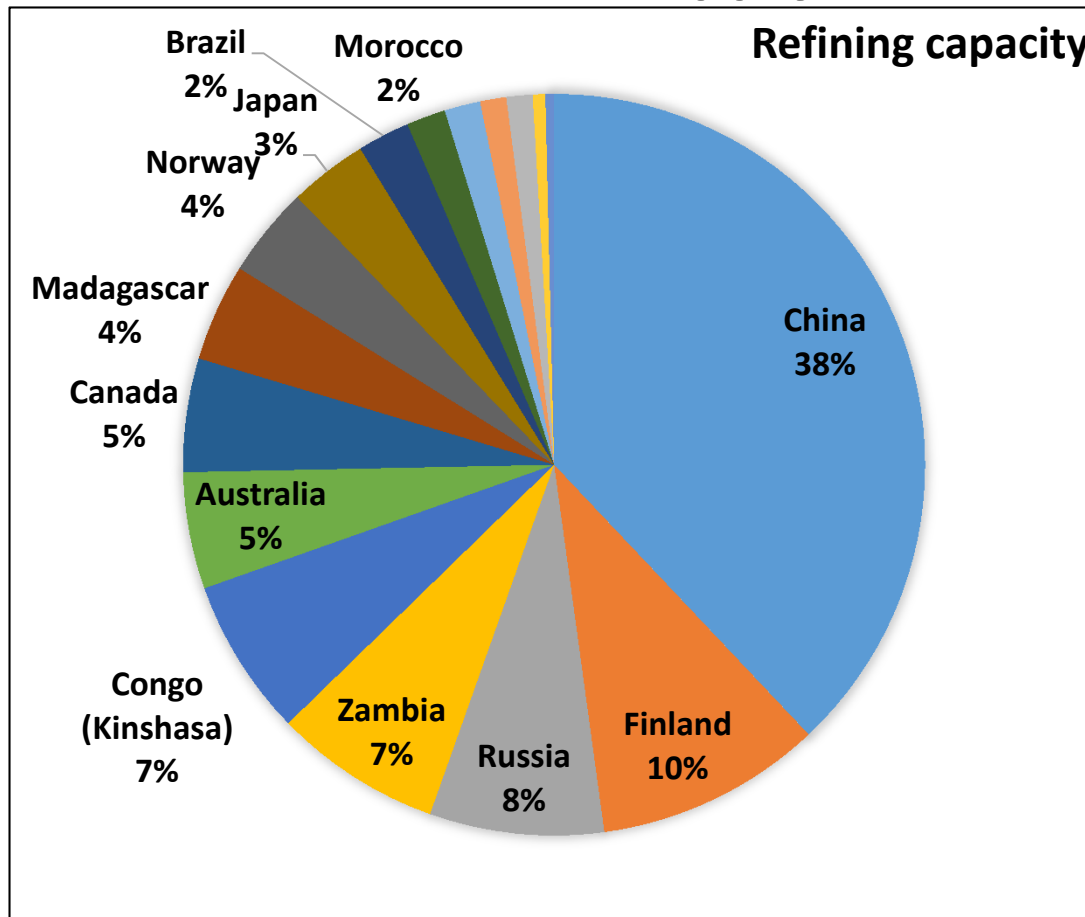
Cobalt production is highly concentrated



*Map shows only the largest producers which contribute 80% of the global production, cumulatively. Actual concentration in DRC is even higher when considering total production, including smaller projects and informal mining.

- Current cobalt mine production is highly concentrated in the **Democratic Republic of Congo, which produced 62% of global mine production in 2016.**
- Therefore, supply is susceptible to **geopolitical risks associated with the DRC.**
- Map at left shows the largest Co producing assets, accounting for 80% of world production.
- **New projects outside of current production zones also are being developed.**
- **But, the copper belt in Central Africa still accounts for the largest cobalt reserves in the world.**
- Cobalt sulfate, the chemical compound relevant for batteries is a downstream product of processing cobalt.
- Cobalt sulfate prices have risen in correlation with cobalt LME prices, as well.

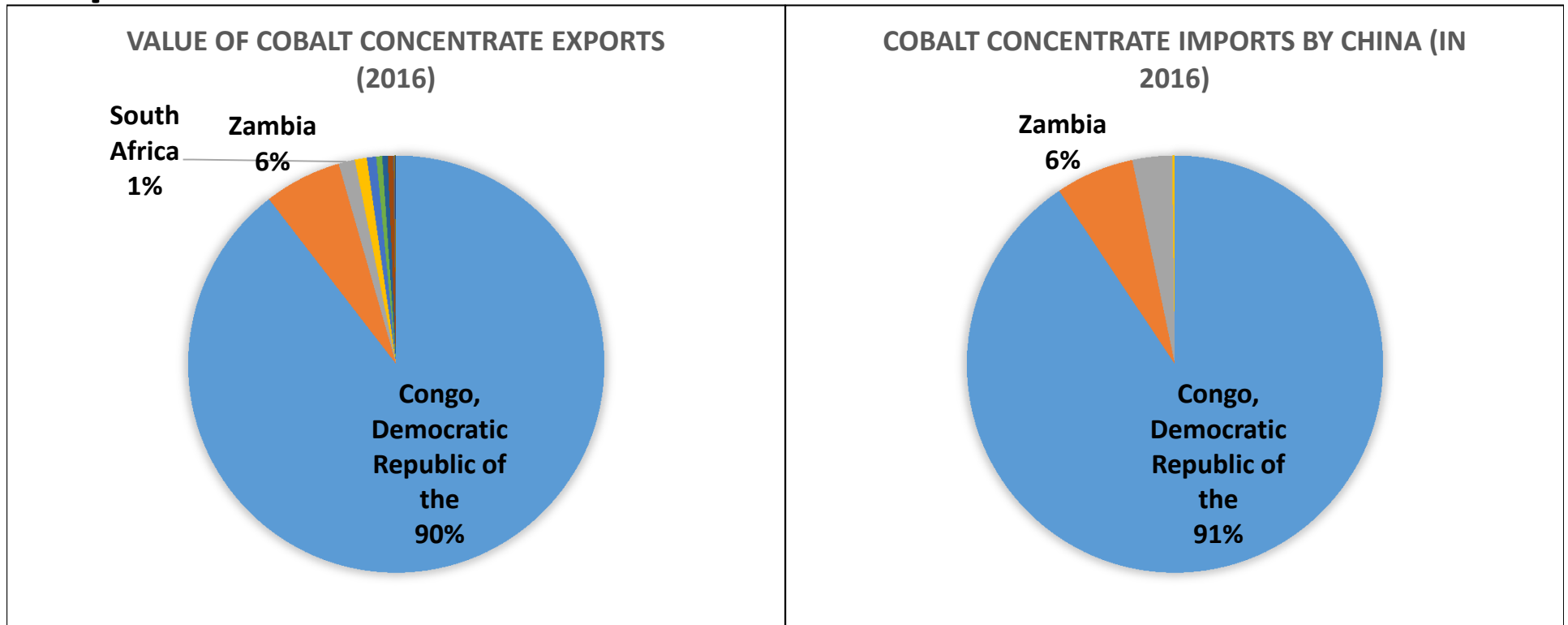
China has the world's largest cobalt refining capacity and dominates the cobalt downstream supply



*Data source: US Geological Survey 2015

- Per USGS estimates, world cobalt refining capacity was close to 132,000 tons of annual refined cobalt production, as of Dec 2015.
- **38% of refining capacity is in China, 10% in Finland, and 8% in Russia.**
- **DRC and Zambia, the largest cobalt concentrate producers, have only 7% each.**
- More refining capacity has been built, and is under construction, since Dec 2015, in China and other parts of the world.
- **In 2015, China produced over 50% of world's refined cobalt.**
- **Cobalt production may become concentrated in China, creating the potential for artificial shortages for battery manufacturers outside of China.**

China dominates almost exclusively as a buyer of cobalt exports out of Africa



*Data source: International Trade Centre UNCTAD/WTO (ITC)

- **The DRC exported over 90% of the global cobalt export (by value) in 2016. Zambia exported close to 6%. Cobalt concentrate is refined to produce pure cobalt cathodes, powder, or ingots. In 2016, the total value of cobalt exports was close to \$ 218 million. The DRC exported \$195 million and Zambia exported \$13 million.**
- **China imported cobalt concentrate valued at \$195 million from the DRC, almost 100% of DRC exports. China imported concentrate valued at \$13 million from Zambia, almost 100% of Zambia exports. Other international trade partners for China were Tanzania and South Africa.**

Future production dynamics and key risks

Future production dynamics:

- Even though the **current** cobalt mine production is highly dependent on the DRC, **future** production may be more geographically diverse
- Various estimates are that almost 160 cobalt projects are under development in Australia, currently in feasibility and exploration phase, and 2 have started construction.
- Similarly more than 90 projects are under exploration and feasibility phases in Canada.
 - At the same time, fewer than 25 projects are estimated to be under feasibility or exploration stage.
- It is important to note that only a small fraction of the projects under feasibility actually become producing assets, and that too after several years of development.
- The number of projects may not be directly related to tonnage. For example, the Kamoto project being jointly developed by Katanga Mining Ltd and the DRC is expected to hold the world's third largest cobalt reserve, among all other producing assets.

Key risks

- Supply shortage creates bottlenecks in battery manufacturing.
- Demand outpaces supply expansion creating a medium term period of high cobalt prices, hence high raw material cost for batteries.
- Cobalt production is concentrated in China, creating potential for artificial shortages for battery manufacturers outside of China and raising trade and intellectual property concerns.
- The DRC government restricts cobalt exports and/or faces increased scrutiny for mining practices.
- Slow growth in downstream processing facilities, like the refining and cobalt sulfate manufacturing.

Appendix – Scenario Assumptions

Battery markets		EIA Low	EIA Base	EIA High	OEM Announcements - Low	OEM Announcements - High
Electric vehicles	EV Stock 2020 (millions)	5.6	9.2	9.7	9	20
	EV Stock 2025 (millions)	24.7	41.3	63.2	40	70
	Share of BEV	33%	67%	67%	67%	67%
	Share of PHEV	67%	33%	33%	33%	33%
Stationary storage (Electrochemical)	Cumulative storage 2020	20 GWh	20 GWh	20 GWh	20 GWh	20 GWh
	Cumulative storage 2025	40 GWh	40 GWh	40 GWh	40 GWh	40 GWh
Consumer electronics	CAGR 2017-2025	8%	8%	8%	8%	8%
Other markets	CAGR 2017-2025	2%	2%	2%	2%	2%

EIA = U.S. Energy Information Administration, www.eia.gov; OEM = original equipment manufacturers.