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Battery raw materials

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Briefing note on raw materials for batteries in electric vehicles

Background

Driven by concerns about climate change, air pollution and energy security the world is undergoing a fundamental transition towards a low carbon future. Changes in the transportation sector will profoundly affect the daily life of billions of people across the globe.

Many nations are planning for this transition and are actively promoting the change from internal-combustion engine (ICE) powertrains to electric vehicles (EV). China has led the world in this with many new policies introduced since 2010 to accelerate the development of its EV industry. The UK has ambitious plans to abolish the sale of new ICE light vehicles by 2040 and for all new vehicles to be zero emission by 2050. The UK Industrial Strategy and Automotive Sector Deal (2018) outlined the support that the government will make available for development of the EV sector in the UK. Currently, this strategy does not make any mention of raw materials, and gives no consideration to future demand and security of raw material supplies.

Demand issues

Since 2010 global EV sales have grown rapidly, led by China and followed, at some distance, by USA, Europe and Japan (Figure 2). However the market remains small, with EV currently comprising much less than 1 per cent of the global vehicle fleet. Future growth is difficult to quantify, but the IEA forecast in 2017 that the global EV stock would grow from 2 million in 2016 to 40–70 million cars on the road by 2025 (International Energy Agency 2017). This will require rapid and massive expansion of the global battery manufacturing capacity, the installation of charging infrastructure and significant technological progress to meet the requirements of cost, performance, safety, customer acceptability and sustainability.

The growth in the global EV fleet will inevitably lead to increased demand for raw materials. Lithium-ion batteries (LIBs) have become firmly established as the preferred battery system for many EV manufacturers. The key constituents of LIBs are lithium (Li), cobalt (Co), nickel (Ni) and manganese (Mn) which are used for the battery cathodes (Figure 1), and graphite used in the anodes. Various classes of LIBs are currently used, the most important for EV being lithium nickel manganese cobalt oxide (NMC) type. Within the NMC class there are many commercially available compositions which vary considerably in the relative proportions of Ni, Mn and Co used. Changes to the chemistry of the electrolyte and of the anode materials used in LIBs may also be implemented within a few years. Uncertainties over battery chemistry, the balance between battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV), and the rate of market penetration across the globe, combine to make forecasting future material demand highly speculative. One forecast suggests compound annual growth rates between 2017 and 2025 of EV demand for Ni, Co and Li at 39%, 25% and 26%, respectively

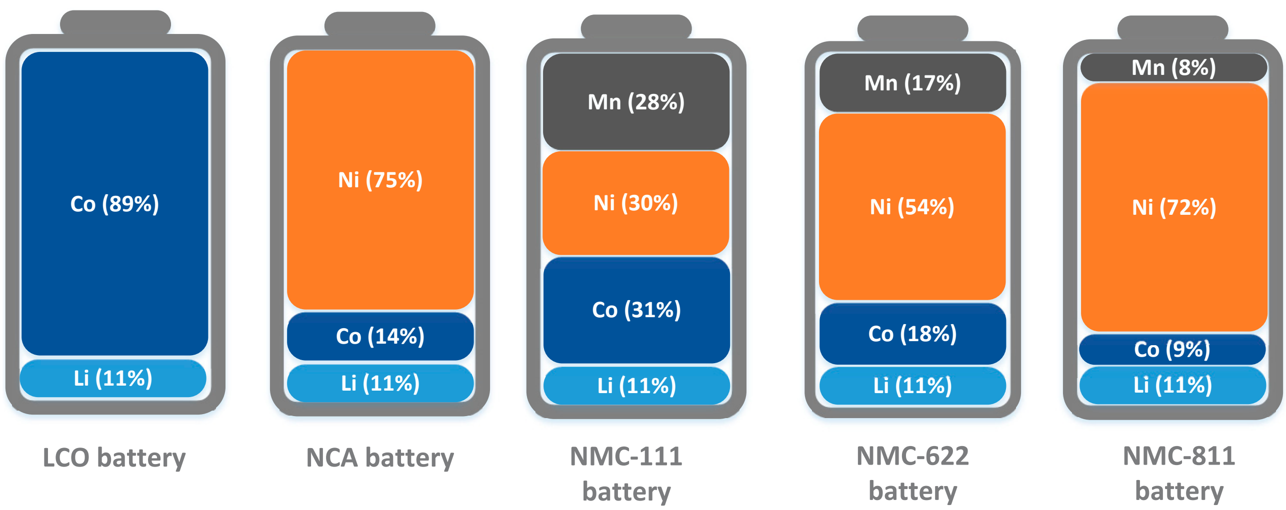

Figure 1 Li-ion battery types and their key constituents (based on figures by Olivetti et al. 2017).

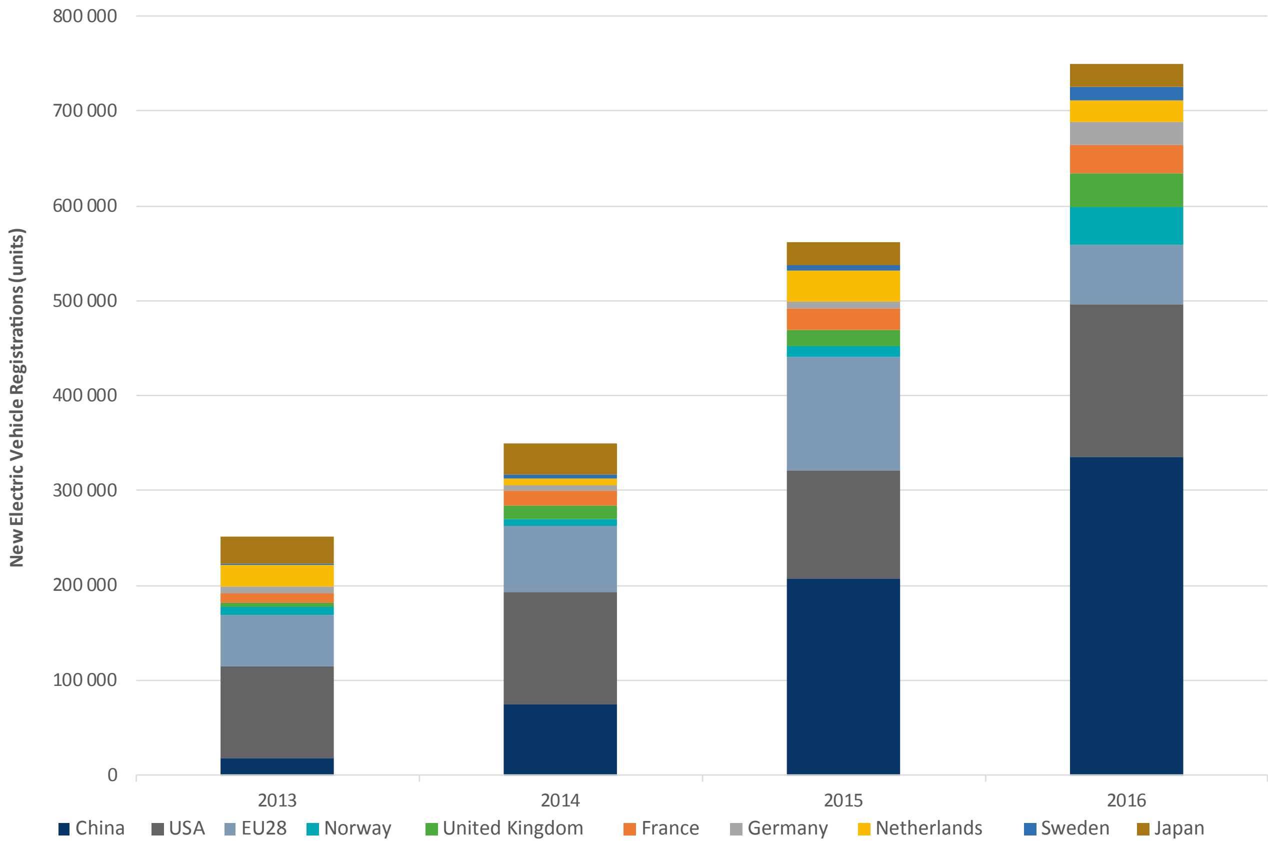

Figure 2 New electric vehicle registrations in key countries that represent over 80% of the global market share (2013–2016). Data from: International Energy Agency, 2017; ACEA, 2018; China Association of Automobile Manufacturers, 2018; Japan Automobile Manufacturers Association, 2018.

(Hamilton 2018). Looking at this another way, forecast EV demand in 2030 for Ni will be 1.1 million tonnes (56% of total global Ni demand in 2016) and for Co 314 000 tonnes (314% of total supply) (Glencore 2018). Increasing demand from other industry sectors may also lead to competition for the supply of the same raw materials and has also to be taken into account when considering EV demand.

Supply issues

All raw materials are derived from the Earth's crust and without them there would be no manufacturing and no recycling. However the importance of metals and minerals supply is rarely considered in manufacturing. In order to establish and maintain a UK EV industry that includes the manufacture of batteries it is essential to procure adequate, secure and sustainable long-term supplies of the essential raw materials. However, several other countries have similar aims. In the past 5 years China has established a strong lead in setting up its EV industry by implementing policies to develop its domestic market and to support the necessary R&D and industrialisation to underpin large scale manufacturing. China now has a large metal refinery capacity, is a major player in the production of intermediate products and components and is ahead of every other nation in the manufacture of battery cells. At the same time, China has also pursued a vigorous policy of securing the battery raw materials for its EV industry from overseas. This has involved a variety of actions, from investment in overseas mining operations to long-term supply contracts with miners.

This complex and uncertain background has caused some countries and corporations to become concerned about the ability of commodity markets to provide the required amounts of the essential battery materials, at the right time, at the right price and sourced in a responsible manner. The problems are generally considered to be most acute for Co supply. About 60% of global mine supply of Co is from the DRC (Figure 3), where the resources are abundant and where industrial-scale infrastructure is established. However, the DRC is neither politically nor economically stable and consequently is not a favourable target for investment. New mining laws introduced in the DRC in early 2018 may provide a further deterrent to investors. In addition, the widespread use of child labour in mining, as in DRC, is becoming increasingly unacceptable to most Original Equipment Manufacturers (OEMs) in the West. More than 90% of the DRC's Co production is shipped to China for refining and processing. This high level of Co supply concentration in the DRC is difficult to mitigate because Co resources are not geologically abundant. There is only one mine in the world, in Morocco, where Co is the primary product. Elsewhere Co is a by-product of either Cu mining, as in DRC and Zambia, or Ni mining, as in Canada or Australia. Up to now the small size of the global market for Co metal (100 000 tonnes per annum) and its price have meant that Co production alone cannot support mining. Other sources of Co may be available in the long term, for example from different geological environments (seafloor deposits, shales, etc), from mine waste and from recycling. However, such sources cannot make significant contributions to increasing supply in the short term. In addition, knowledge of their potential to provide alternative sources of Co is limited, as they have not been investigated in the past.

The supply of Li and Ni are perhaps less challenging, with established producers and new projects able to meet demand in the short term (Figure 4). However, if demand increases as projected, then supply problems with these commodities may also arise. Another potentially serious concern relates to the adequacy and location of the metallurgical infrastructure required to extract and refine the battery metals and to produce chemicals of the specification required for use in batteries. The capacity to undertake these activities, and to produce the cathodes and battery cells, are currently strongly concentrated in China, South Korea and Japan. To ensure long-term Co and Li supplies western companies, such as VW and BMW, are following the example of Chinese OEMs and seeking long-term supply contracts with miners.

Although the level and timing of future demand for battery materials are uncertain, there are serious concerns about where these materials will come from, and whether they can be mined and processed in a timely manner, while still complying with a raft of economic, technical, environmental and social requirements. Fears of supply shortages of these metals have led to rapid price inflation over the past 2–3 years, with Co more than doubling in the last 12 months alone. This complex, dynamic and uncertain situation is not conducive to robust long-term planning and decision making.

Mitigation strategy

There is no simple way to ensure the security of raw material supply required for a UK EV battery industry. The first essential step is to acquire a thorough understanding of the global supply chains of each material, from mining to processing, extraction, refining, manufacture, recycling

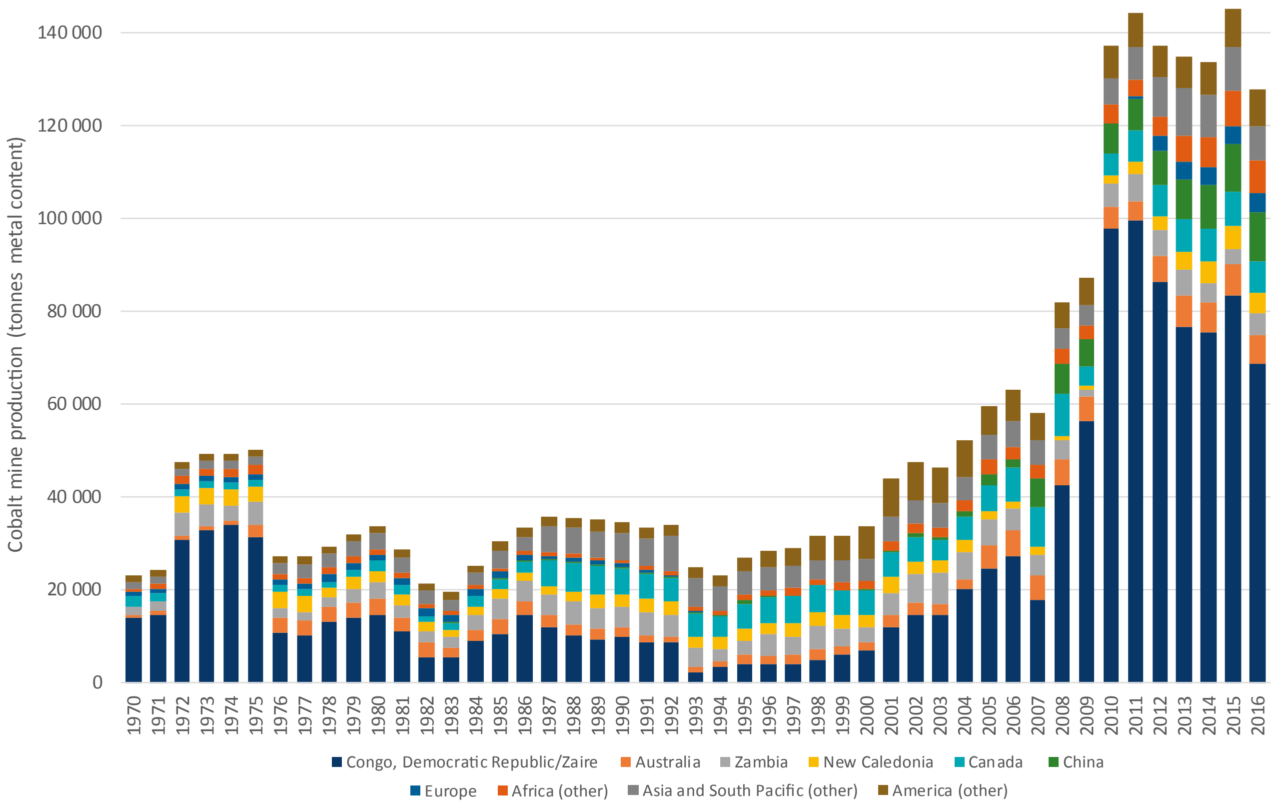

Figure 3 Time series of global cobalt production per country (1970–2016). Data from BGS World Mineral Statistics Database (www.bgs.ac.uk/mineralsuk/statistics/home.html).

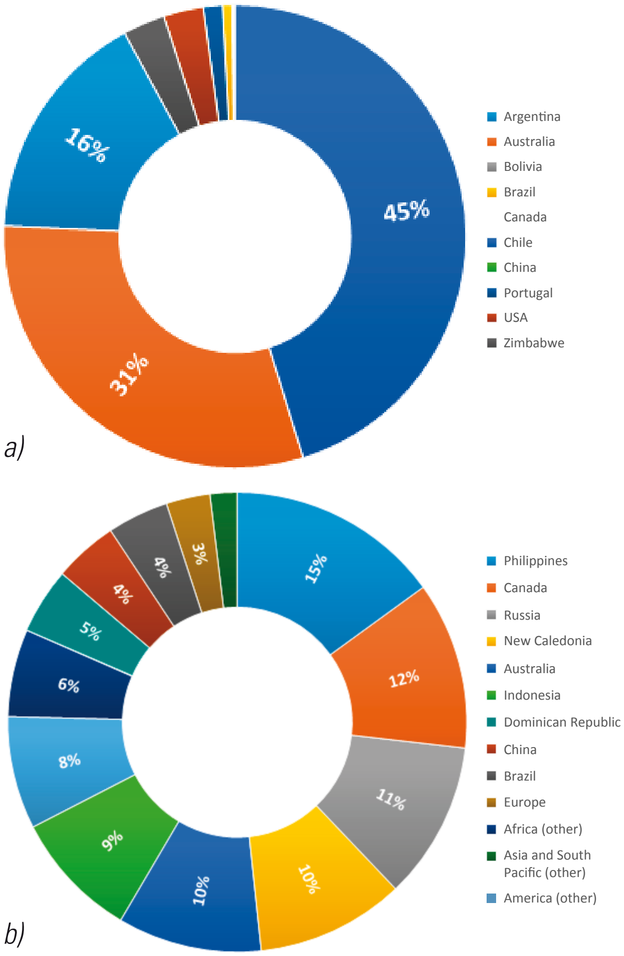

Figure 4 World production shares for 2016 by country of (a) lithium minerals (lithium content) and (b) nickel mine production (metal content). Data from BGS (Brown et al. 2018).

and disposal. This would provide a basis for understanding material flows and stocks in society, and for identifying the location and nature of supply chain vulnerabilities. This would in turn facilitate informed strategies and interventions to ensure access to materials and components for the UK EV industry.

Dynamic monitoring of the raw material cycles of essential raw materials would facilitate early recognition of supply risks and the development of tailored mitigation strategies, improved forecasting and better-informed decision making. These should be supported by a UK-focussed policy on security of supply and traceability of material flows. The lack of adequate investment for the development of new mining projects worldwide is a serious obstacle to increasing supply at present. However, public-private partnership investments and other financing models might help in this regard. At the company level, mitigation might include changing procurement practice and risk assessment methodologies, entering into long-term contracts with material providers at different points in the supply chain and investing in mining projects.

The understanding of battery material cycles provides important insight into the global sectors and players involved and has implications beyond supply disruption concerns. For example, due diligence compliance and issues related to industry reputation, environmental impacts due to bad practice, social impacts associated with conflict minerals and child labour, can be elucidated using supply chain audits and mapping.

The challenges for the UK government and industry are both dynamic and multifaceted. However, without in-depth understanding and monitoring of the battery raw material cycles, it will be difficult to develop a robust strategy for ensuring secure material supplies required by the UK EV battery sector.

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