Electric vehicles and a circular economy: the case of cobalt in lithium-ion batteries in the EU

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Abstract

The transition to electric vehicle (EV) requires a significant amount of mined metals. Whilst lithium has been the primary research focus of studies on EV battery material demand, cobalt has only until recently received increased attention (Ellingsen et al., 2014). Due to the supply risks associated with cobalt and its economic importance, the European Union (EU) regards cobalt as a critical material. One of the supply risks are cobalt's unique metal features, making it difficult to substitute the metal. Another risk is the high production and reserve concentration located in the Democratic Republic of the Congo. Furthermore, cobalt is almost entirely mined as a co-or by–product, leaving its supply highly depend on copper and nickel production (Mistry et al., 2016).

One important strategy to reduce the mining and supply risks is to apply circular economy principles to reduce, reuse and recycle minerals in general (Tangtinthai et al., 2019) and EV batteries in particular (Olivetti et al., 2017). Recent studies have illustrated the theoretical potential of metal supply from recycled EV batteries, but have neglected key issues such as collection rates, battery degradation, policy frameworks and the different (future) battery technologies. In addition, most of these studies focus on recycling and rarely take reuse into consideration. To overcome these gaps, this study presents an in-depth analysis of circular economy principles applied to EV batteries. It will elucidate the following question: what are the key challenges and opportunities in the European Union of partially substituting primary Co by recycling and reusing EV batteries?

A dynamic material flow analysis (Huang et al., 2012) was established to quantify current and future cobalt flows and stocks required for EV batteries for the EU passenger vehicle fleet. Current EV models use different battery chemistries that contain different amounts of cobalt. For that reason, a base year of 2017 was created using detailed data inputs, including all EV models registered in the EU 28 in 2017and their cobalt content based on the battery technology used. In addition, data on battery end-of-life, vehicle collection rates, battery production and recycling capacity were calculated to understand future cobalt flows. Based on technological and market developments, a business as usual scenario was modelled to provide a baseline of cobalt flows up to 2050. Three additional scenarios where identified to model possible improvements for recycling and reusing, including a policy-driven, a business model change and a technology-driven scenario.

The business as usual scenario shows that recycled cobalt from EV batteries is limited due to the small battery recycling capacities in the EU. Reuse of EV batteries in less demanding applications is also expected to be marginal due to the expectation that consumers are unlikely to early replace the EV battery because of the high cost. As a result, batteries have a

limited capacity left after a long lifetime in the EV and are unsuitable for reuse. The three scenarios however, demonstrate that an increase in recycling capacity and higher collection rates, can result in a large amount of recycled cobalt flowing back to the production of new EV batteries. In addition, a battery lease business model that stimulates early replacement of EV batteries after 8 years, results in a high amount of battery reuse, and thus increases the battery lifetime. However, even in the best-case scenario, recycling or reuse only become attractive from 2035 onwards, highlighting that primary cobalt extraction remains a potential bottleneck of cobalt supply in the coming decades.

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