The global life cycle of rechargeable Lithium ion batteries: what natural resource savings can be gained through recycling?

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Rechargeable Li-ion batteries are ubiquitous in our modern society with applications in consumer products like mobile phones, personal digital assistants and laptops. It is obvious that these rechargeable batteries show a better environmental profile than primary batteries, but even a step further is to recycle rechargeable Li-ion batteries. This makes sense from several points of view, but particularly reduction of depletion of natural resources such as Cobalt and Manganese metals is a prominent driving force: it is estimated that battery applications account already for nearly 25% of worldwide cobalt demand.

Quantification of the environmental benefits induced by recycling rechargeable Li-ion batteries is not a piece of cake: the material flows have an international dimension giving rise to lack of accessibility and transparency of information; the complex nature of the processes induce allocation difficulties; and also the definition of recycling can be questioned: do we look at the overall mass of the battery or at specific exhaustible metals? In this contribution, we have established two life cycle scenarios for advanced Li-ion battery cathode materials: one scenario based on Cobalt and Nickel recovered from batteries and one based on freshly mined Cobalt and Nickel. It must be emphasized that the former scenario is not yet common practice today. It is anticipated that a much bigger portion of these end-of-life batteries will be recycled in the near future.

To analyze the two scenarios, data on practice spread internationally, including Lithium, Nickel and Cobalt mining, Manganese production, Nickel and Cobalt recycling through pyrometallurgical and hydrometallurgical processes, and battery cathode production have been studied, along with involved transport processes. Secondly, the authors approached the two cases via a resource oriented life cycle approach: exergetic life cycle analysis as described recently in the review of Dewulf et al., Environmental Science & Technology, 42, 2221-2232, 2008, and more specifically in Dewulf et al., Environmental Science & Technology, 41, 8477-8483, 2007. From the detailed study, it turns out that the recycling scenario result in a 51 % natural resource savings, not only because of decreased mineral ore dependency but also because of reduced fossil resource (45% reduction) and nuclear energy demand (57%).