Nickel-cobalt-aluminum batteries nca wellington

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??NCA ?NCA ??? LiNi?CoyAlzO?, x + y + z = 1? NCA,,x ? 0.84, 3.6 V 4.0 V, 3.6 ...

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Acceleration of the energy transition and realization of both national and regional climate commitments require urgent action on a global scale1. These goals depend upon adoption of technologies that facilitate emissions reductions. However, energy systems powered by low-carbon technologies differ profoundly from current systems of fossil fuel trade and infrastructure. The manufacturing of solar photovoltaic plants, wind farms, and electric vehicles (EVs) - technologies crucial to lowering emissions - generally requires considerable volumes of specialty minerals, with mineral intensity varying greatly across different technologies2,3,4.

Meeting the mineral demands associated with electrifying the light-duty vehicle fleet warrants particular attention given the transportation sector''s contribution to CO2 emissions. Owing to an existing internal combustion engine vehicles'' (ICEVs) dependence on fossil fuels, cars, vans, and sport utility vehicles produce nearly half of all transportation-related greenhouse gas emissions, making these vehicles significant contributors to climate change5,6. Electrification offers - by virtue of reduced dependence on fossil fuels - a lower well-to-wheels emissions profile, which can reduce overall emissions relative to the status quo7,8,9,10,11,12.

However, raw material supply chain bottlenecks present potential obstacles for an efficient transition to EVs13,14,15,16. Compared to ICEVs, five minerals- cobalt, graphite, lithium, nickel, and rare earths are used to a significantly higher degree in the manufacturing of EVs. An EV also requires twice the weight of copper and manganese - two additional key minerals, relative to ICEVs2. Higher mineral demands imposed by EVs and the envisioned prospect of widespread electrification as a pathway towards emissions reduction raise the important question: do mineral demands associated with electrifying the light-duty vehicle fleet exceed available supply? If so, by how much? And what are the emissions consequences of disequilibrium in critical minerals market?

Three key characteristics define our approach.

Electrification of the U.S. light-duty vehicle fleet carries the potential to reduce CO2 emissions, public health harm from air pollution, and national dependence on fossil fuels. These societal benefits have prompted the

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EPA to propose stringent emissions standards that de facto necessitate EV adoption. How achievable are the proposed standards given constraints in mineral supply chains?

Realization of EPA prescribed sales volume targets are estimated using both mineral reserve and mineral production estimates (see "Methods" section for details). Unless otherwise specified, estimates presented assume new light duty vehicle sales comprise solely of (and replace) four-door sedans. The robustness of this parameter as it relates to requisite EV sales and mineral demands is subsequently tested under the Heavier Fleet Assumption (see Methods for details). Where our model produces different estimates for each sales scenario, we present results for the medium sales scenario followed by the range across the low and high scenarios in parentheses.

Our key findings are as follows.

Reliance on LFP battery chemistry maximizes the number of EVs supported (989.27 million), followed by NCA (400.37 million), NMC 811 (201.80 million), NMC 523 (90.21 million), and NMC 622 (81.66 million). Moreover, leveraging a combination of LFP and NCA chemistries affords additional EV batteries to be manufactured; namely, available reserves can simultaneously produce 735.19 million LFP batteries and 400.37 million NCA batteries, thereby supporting a total of 1.14 billion EVs. Reliance on NMC 111 exclusively affords the fewest number of vehicles supported (47.71 million), though we recognize that such a scenario may be unrealistic given recent shifts away from NMC 111 chemistries49,50.

Although these results imply that vehicle manufacturers can fully satisfy EV demand using numerous potential major chemistries51, access to geological mineral reserves depends in practice upon mineral production capacity. Whereas reserves refer to long term, cumulative economically viable supply, production rates reflect existing extraction capacity. Consequently, in addition to solely considering geological reserves, planners must assess whether available mineral production capacity can enable realization of the EPA''s electrification targets.

Overview of mineral demands versus available supply (Optimal chemistry - NMC 811).

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