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Electric vehicles (EVs) generally have a reduced climate impact compared to internal combustion engine vehicles1. Together with technological progress and governmental subsidies, this advantage led to a massive increase in the demand for EVs2. The global fleet of light-duty EVs grew from a few thousand just a decade ago to 7.5 million vehicles in 20193. Yet, the global average market penetration of EVs is still just around 1.5% in 2019 and future growth is expected to dwarf past growth in absolute numbers3.

Lithium-ion batteries (LIBs) are currently the dominant technology for EVs2. Typical automotive LIBs contain lithium (Li), cobalt (Co), and nickel (Ni) in the cathode, graphite in the anode, as well as aluminum and copper in other cell and pack components. Commonly used LIB cathode chemistries are lithium nickel cobalt manganese oxide (NCM), lithium nickel cobalt aluminum oxide (NCA), or lithium iron phosphate (LFP), although battery technology is currently evolving fast and new and improved chemistries can be expected in the future2,4.

Due to the fast growth of the EV market, concerns over the sustainable supply of battery materials have been voiced. These include supply risks due to high geopolitical concentrations of cobalt5,6 and social and environmental impacts associated with mining7,8, as well as the availability of cobalt and lithium reserves9 and the required rapid upscaling of supply chains to meet expected demand5.

a NCX scenario. b LFP scenario. c Li-S/Air scenario. See Supplementary Fig. 4 for the Sustainable

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Development scenario. See Supplementary Fig. 5 for battery sales in units. LFP lithium iron phosphate battery, NCM lithium nickel cobalt manganese battery, Numbers in NCM111, NCM523, NCM622, NCM811, and NCM955 denote ratios of nickel, cobalt, and manganese. NCA lithium nickel cobalt aluminum battery, Graphite (Si) graphite anode with some fraction of silicon, Li-S lithium-sulphur battery, Li-Air lithium-air battery, TWh 109 kWh.

a Primary material demand. b materials in end-of-life batteries. See Supplementary Fig. 7 for other materials. STEP scenario the Stated Policies scenario, SD scenario Sustainable Development scenario, Mt million tons.