The transition to a low-carbon economy will be material-intensive. Production of these materials (from mining to manufacturing) incurs environmental costs that vary widely, depending on the geology, mineralogy, extraction routes, type of product, purity of product, background system or manufacturing infrastructure. Understanding the impacts of the raw materials underpinning the low-carbon economy is essential for eliminating any dissonance between the benefits of renewable technologies and the impacts associated with the production of the raw materials. In this Review, we propose an integrated life cycle assessment and geometallurgical approach to optimize the technical performance and reduce the environmental impact of raw material extraction. Life cycle assessments are an effective way of understanding the system-wide impacts associated with material production, from ore in the ground to a refined chemical product ready to be used in advanced technologies such as batteries. In the geometallurgy approach, geologists select exploration targets with resource characteristics that lend themselves to lower environmental impacts, often considering factors throughout the exploration and development process. Combining these two approaches allows for more accurate and dynamic optimization of technology materials resource efficiency, based on in situ ore properties and process simulations. By applying these approaches at the development phase of projects, a future low-carbon economy can be achieved that is built from ingredients with a lower environmental impact.