

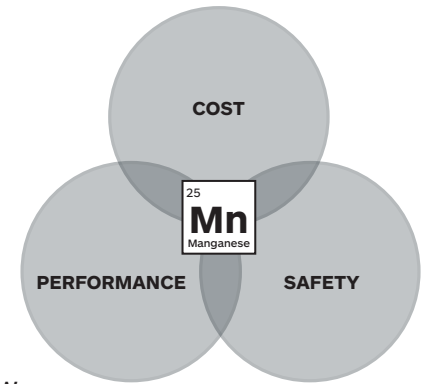
MANGANESE: A KEY TO AMERICA'S EV FUTURE



While lithium, nickel and cobalt dominate the headlines, manganese may be the critical mineral that helps the U.S. auto industry build more electric vehicles faster, more sustainably, and more affordably. Here are 5 reasons why:

1 | Manganese lowers the cost of high-performance EV batteries.

Manganese acts as a stabilizer in nickel manganese cobalt (NMC) battery cathodes, the most commonly used in the current EV market, reducing the need for expensive cobalt and increasing safety without compromising driving range.



2 | Manganese improves the performance of lower-cost EV batteries.

When added to the traditional lithium iron phosphate (LFP) cathode, which is increasingly used for entry-level car models, manganese improves energy density—and thus driving range—while keeping costs low.

3 | Manganese is safe, stable, and abundant.

The fifth most abundant metal in the Earth's crust, manganese is plentiful compared with other common battery metals. According to Umicore, 90% of the manganese produced today goes to the iron and stainless steel industry while less than 1% is used for batteries—but that is shifting. BloombergNEF expects demand for battery-grade manganese sulfate to exceed future supply capacity in 2023.

FACT: Manganese was one of only five minerals included in the 2022 Defense Production Act.

4 | Manganese is attracting interest from researchers and automakers looking for alternatives to more costly battery chemistries.

With Russia being a major supplier of nickel and cobalt mined primarily in the Congo, interest in alternative cathode chemistries is growing as end-users search for more stable supply chains with safe labor practices. Tesla and Volkswagen have both signaled an interest in moving away from cobalt and nickel in their lithium-ion battery designs and toward manganese. Among the high-manganese cathode candidates: lithium manganese nickel oxide (LMNO); lithium iron manganese phosphate (LMFP); and nickel manganese-based cathodes (NMX), which are 25% cheaper than NMC and displace cobalt entirely.

FACT: Demand for battery-grade manganese is expected to increase 15x from 2020 to 2031, according to utilities research firm E Source.

5 | Manganese can be sourced and processed domestically.

Today, the U.S. is 100% reliant on foreign sources for manganese, with 97% of the manganese metal in North America imported from China. **South32's Hermosa Project, located in Southern Arizona, is the only advanced manganese project in the US as of 2023 that has a viable pathway to produce battery-grade manganese to supply domestic demand.**

FACT: Only four countries with U.S. free trade agreements have the potential to supply manganese ore, metal, or sulphate: Australia, Canada, Mexico, and Morocco.

“ I think there’s an interesting potential for manganese... the materials used to produce these batteries at a very large scale need to be common materials or you can’t scale. ” - Tesla CEO Elon Musk at the Tesla Gigafactory Berlin event, March 2022

SPOTLIGHT: How manganese factors into the two major lithium-ion EV battery chemistries

Cathode type	Lithium iron phosphate (LFP)	Nickel manganese cobalt oxide (NMC)
Known for	Lower cost, longer lifespan, shorter range; becoming more popular for entry-level models, particularly in China	High performance, more expensive; most common in North American and European markets
Benefits of increasing manganese content	Improves energy density and thus driving range, while keeping costs low	Lowers cost by reducing need for cobalt and 370-chemistry nickel; acts as stabilizer to increase safety without compromising range
Notable customers	Base model Tesla Model 3, Ford Mustang Mach-E and F150 Lightning (late 2023)	GM, Ford, Volkswagen, Nissan, Mercedes-Benz, Toyota, Hyundai

“ Manganese may emerge in next-generation cells as a preferred element given its low cost, abundance, and the fact that many manganese-based cathodes are relatively safe. ”

June 2021 White House report, “*BUILDING RESILIENT SUPPLY CHAINS, REVITALIZING AMERICAN MANUFACTURING, AND FOSTERING BROAD-BASED GROWTH*”



Learn more: South32Hermosa.com