MANGANESE:

A KEY TO AMERICA'S EV FUTURE

While lithium, nickel & 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:

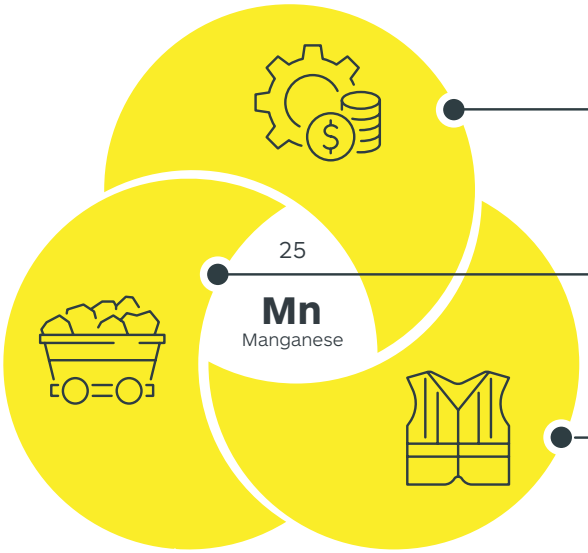
1 **Manganese lowers the cost of high-performance EV batteries.**

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

3 **Manganese is naturally occurring and stable.**

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

5 **Manganese can be sourced and processed domestically.**



COST

PERFORMANCE

SAFETY

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.

03.22 **Tesla CEO Elon Musk** **at the Tesla Gigafactory Berlin Event**

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

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

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

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, F150 Lightning	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.

06.21 White House Report: Building Resilient Supply Chains, Revitalizing American Manufacturing & Fostering Broad Based Growth.

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