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Sector Update | **Thematic**

Investor Report: Manganese Use in Advanced Battery Chemistries

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Executive Summary

Manganese is emerging as a critical mineral in the next generation of lithium-ion battery chemistries, particularly in lithium manganese iron phosphate (LMFP) and lithium manganese rich (LMR) cathodes. These materials offer significant cost and performance advantages over traditional chemistries, such as NMC (nickel manganese cobalt) and LFP (lithium iron phosphate), and are gaining commercial interest due to their safety, sustainability, and supply chain benefits. As OEMs seek alternatives to nickel and cobalt-based batteries, manganese is poised to play a pivotal role. Key developments in the supply chain—especially in Western markets—underscore the strategic value of battery-grade manganese.

Manganese and the Battery Revolution

Manganese is already widely used in NMC cathodes, but its role is expected to increase substantially with the rise of LMFP and LMR chemistries. Compared to nickel and cobalt, manganese is more abundant, cost-effective, and geographically diversified, with key developments in Africa, Europe, North America, and Australia. Demand for high-purity manganese sulfate monohydrate (HPMSM) is expected to grow 10–15x over the next decade.

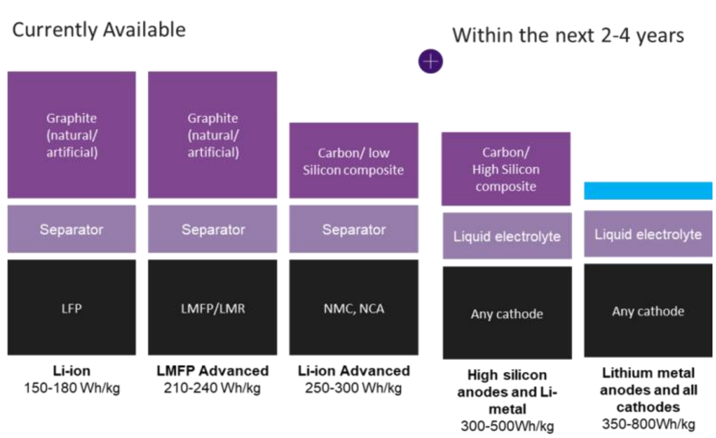
LMFP: The Next Evolution of LFP

LMFP ($LiMn_{0.5}Fe_{0.5}PO_4$) is structurally similar to LFP but offers 20–30% higher energy density, making it ideal for mid-range electric vehicles. It retains the thermal stability and low-cost advantages of LFP while enhancing performance metrics. LMFP contains up to 60% manganese by weight and eliminates the need for nickel and cobalt. Mass production began in China in 2022, with CATL, BYD, and Gotion actively looking to integrate LMFP cells. Western automakers are expected to follow suit within the next 2–3 years. We caution that while China already has 10,000 mt LMFP cathode capacity, which is rapidly increasing, there have been issues with using a full LMFP cathode, as it has been difficult to manufacture. To date, most of the LMFP has been blended with higher-cost NMC. While Chinese research indicates that long-cycled LMFP cells will be made in China, this is something to watch for. Companies such as Shenzhen Dynanonic, Ronbay, and in the UK QinetiQ cell using Integrals Power CAM (which is 80% manganese), are among interesting companies to bring this chemistry to market.

LMR: High Energy Potential with Technical Barriers

Lithium manganese rich (LMR) cathodes, typically layered oxides such as $Li_{1.2}Ni_{0.2}Mn_{0.6}O_2$, offer among the highest theoretical capacities (210–260 mAh/g) at voltages around 3.5–3.7 V. However, in the past, deployment has been slow due to degradation mechanisms such as voltage fade and structural instability during cycling. These issues limit cycle life. As with LMFP, there were issues with manufacturability. Nonetheless, with recent R&D momentum—including GM's plans to commercialize LMR cells by 2028 means LMR remains a high-potential, longer-term opportunity.

Figure 1: Evolution of battery chemistry types



Source: Traubenbach

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Market Trends and Demand Outlook

- Manganese use per EV could grow from ~5 kg to as high as 120 kg depending on pack chemistry and size.
- LMFP batteries could become the dominant chemistry in 5-8 years, particularly in China and Southeast Asia, then rapidly moving West.
- LMR deployment is likely after 2028, pending technical advancements.
- Major OEMs are diversifying cathode chemistries to reduce reliance on nickel and cobalt due to cost, ESG, and geopolitical risk.

Strategic Supply Chain Developments

China currently dominates >90% of HPMSM production. However, several Western projects are emerging:

- **Giyani Metals (TSXV:EMM, BUY (S), C$0.20 target, Alina Islam) (Botswana):** 120 kt/year capacity, vertically integrated, first product shipped May 2025.
- **Euro Manganese (TSXV:EMN, Not Rated) (Czech Republic):** Reprocessing tailings to produce HPMSM, targeting 100 kt/year.
- **Manganese X Energy (TSXV:MN, Not Rated) (Canada)** and others are also in pre-development phases.
- **South32 (ASX:S32, Not Rated) (USA)** is working to build a mining complex at Hermosa, Arizona.
- **Vibrantz Technologies (Private) (Mexico)** 45kt/year HPMSN in their Tampico.
- **Element 25 (ASX:E25, Not Rated) (Australia/USA)** announced plans to build an HPMSM refinery in the United States

European and North American HPMSM is already trading at a premium of ~$1,700/tonne over Chinese supply due to ESG and security of supply considerations.

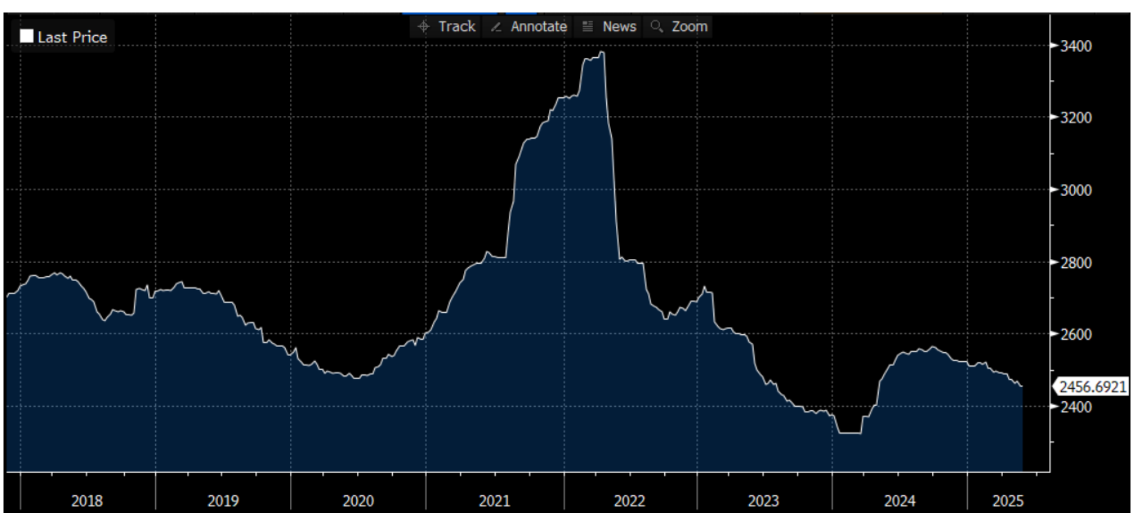
Investment Implications

Investors should monitor:

- LMFP cell adoption curves among OEMs (BYD, VW, GM)
- HPMSM spot and contract pricing trends, especially the Western Premium
- Project milestones from Giyani, Euro Manganese, and other non-Chinese producers
- Regulatory incentives tied to improve localized metals production

Manganese's strategic relevance is underappreciated compared to lithium, nickel, and cobalt. As LMFP and LMR gain traction, manganese could become a key enabler of scalable, sustainable electrification.

Figure 2: Manganese price chart



Source: Bloomberg

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Conclusion

With the battery sector undergoing rapid transformation, manganese-based cathodes offer a unique value proposition: high energy density, safety, low cost, and a reduced geopolitical footprint. While LMFP is now in commercial scale-up, LMR holds promise for the next wave of ultra-high-energy nickel bearing chemistries. Western investors and supply chain actors are well-positioned to benefit from the coming surge in demand for high-purity manganese products.

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Company Name	Ticker Symbol	Disclosures
Giyani Metals Corp.	TSXV:EMM	

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