Projected Electric Vehicle REE and CM Demands Versus Global Mined Supplies

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Introduction

- With the recent increase in our technology. More than ever, car manufacturers are changing to electric.
- With this increase in demand for electric vehicles, their motors and batteries could become more expensive to make due to the need for Rare Earth Elements.
- Rare earth elements (REE) are a group of 15 referred to as the lanthanide's series in the periodic table.
- Most notably of the 15 to the electric car industry are, Dysprosium and Neodymium.
- The demand for those key elements is increasing due to the rare earth consumption for electric traction motors and critical minerals for Li-ion batteries in EVs.

- There are 3 main classifications of elcetic veihicles. Fully Elecric (BEV), Hybrid (HEV), and Plug-in Hybrid (PHEV).
- Nearly all BEV's use traction motors based on rare earth permanent magnet, NdFeB.

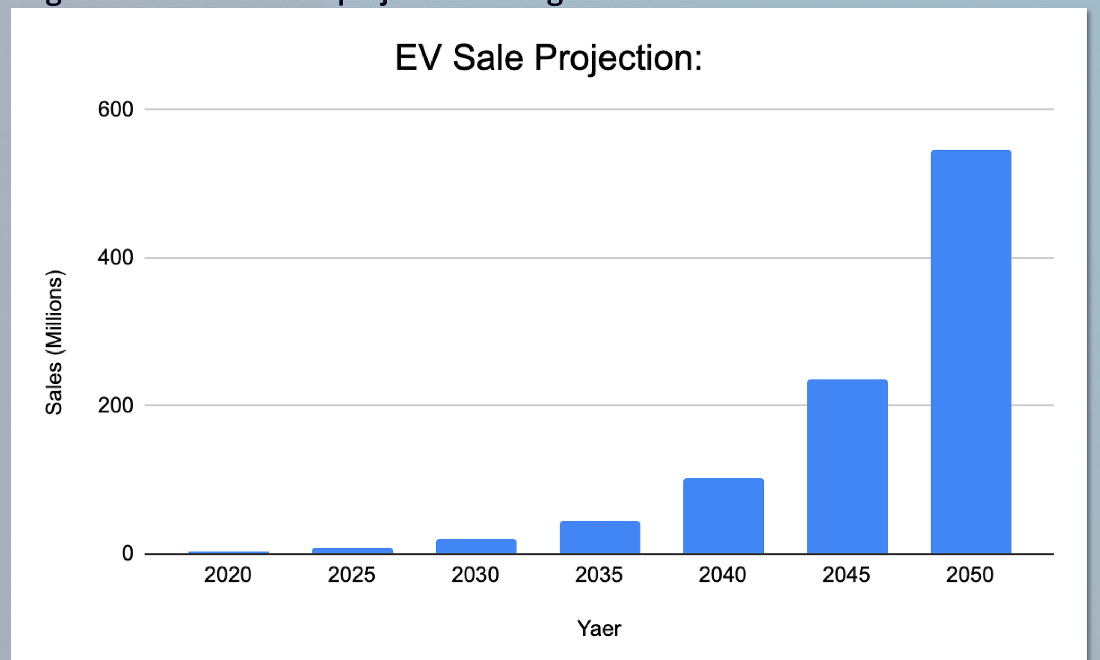
Research Question

- How does the available mined REE and CM compare to projected demand by electric vehicle demand represented by traction motors based on rare-earth permanent magnets and Li-ion batteries reliant upon several critical minerals?

Method

- Identify Material Intensities for EV traction motors and batteries
- Estimate EV adoption rates
- Calculate projected REE and CM requirements
- Compare REE and CM demand to mined global production levels

Figure 1: Global EV sale projection through 2020 - 2050



Source: Bloomberg, june 27th, 2022

Results

Table 1: Material Intesities for average Li-Ion battery, Plug-in Hybrid, and Battery Electric Car

Element	Battery	PHEV*	BEV*
REE's (g)			
Dysprosium	-	165.72	224.63
Neodymium	-	552.79	749.3
Critical Minerals(kg)			
Nickel	20.4	17.8	58.3
Cobalt	20.4	2.6	10.6
Lithium	7.5	2.1	8.5
Manganese	31.2	2.1	5.5

*Includes traction motors and all other auxilary motors, ex power streering, power seats, etc.

- A CAGR was used to determine an annual growth rate based on documented previous years for specific REE's, such as Dysposium and Neodymium, to project future demand.

$$V_f = V_i\,(CAGR + 1)^n$$

Where V_f is is final value, V_i is the initial value, and n is the period that has elapsed.

- The demand was calculated by implementing the CAGR for EV sales, and EV material intensities.

Table 2: Supply and demand of Critical Minerals for Li-ion Batteries

	Lithium (kt)			Nickel (kt)			Cobalt (kt)			Manganese (kt)		
Year	Supply	Demand	%	Supply	Demand	%	Supply	Demand	%	Supply	Demand	%
2020	83	29	35	2,510	196	8	142	36	25	20	19	94
2025	262	79	30	3,889	537	14	418	98	24	28	51	182
2030	685	181	26	5,601	1,234	22	1,026	226	22	37	118	316
2035	1,791	418	23	8,067	2,853	35	2,522	523	21	49	272	550
2040	4,687	964	21	11,619	6,575	57	6,198	1,205	19	66	627	955
2045	12,265	2,224	18	16,735	15,172	91	15,231	2,781	18	87	1,446	1,661
2050	32,091	5,135	16	24,103	35,039	145	37,429	6,423	17	116	3,339	2,891

Percentage is calculated as ratio of projected demand relative to supply

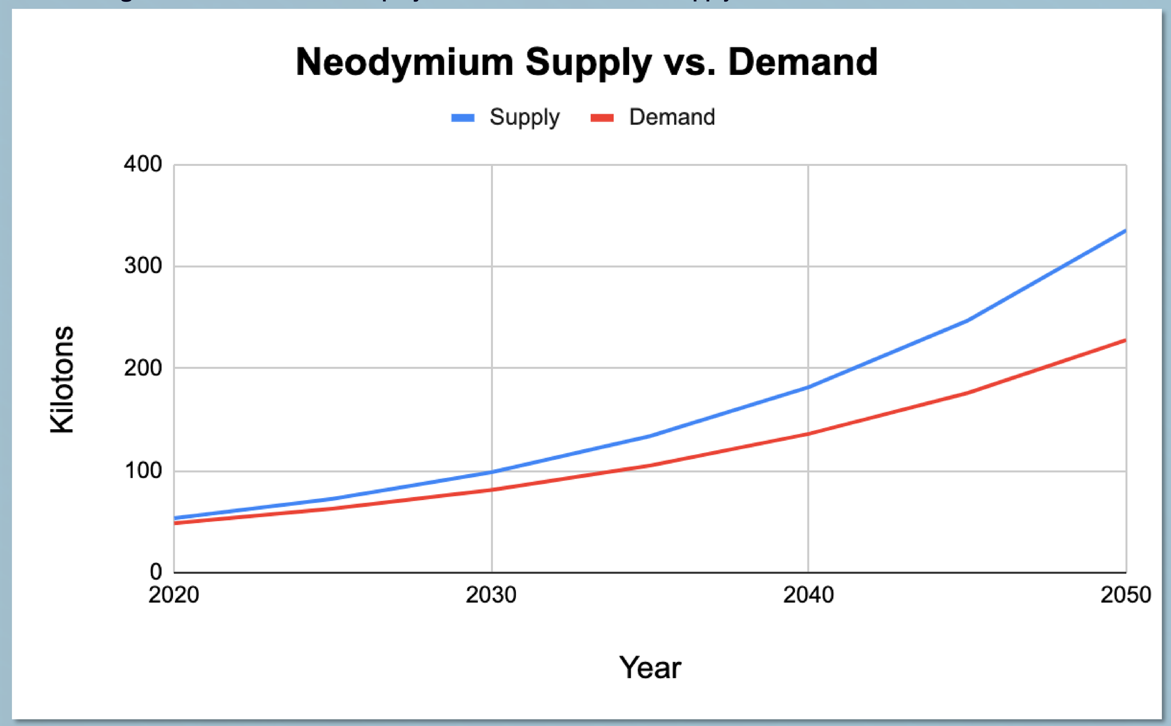


Figure 2: Projected Neodymium Supply vs. Demand through 2020 - 2050

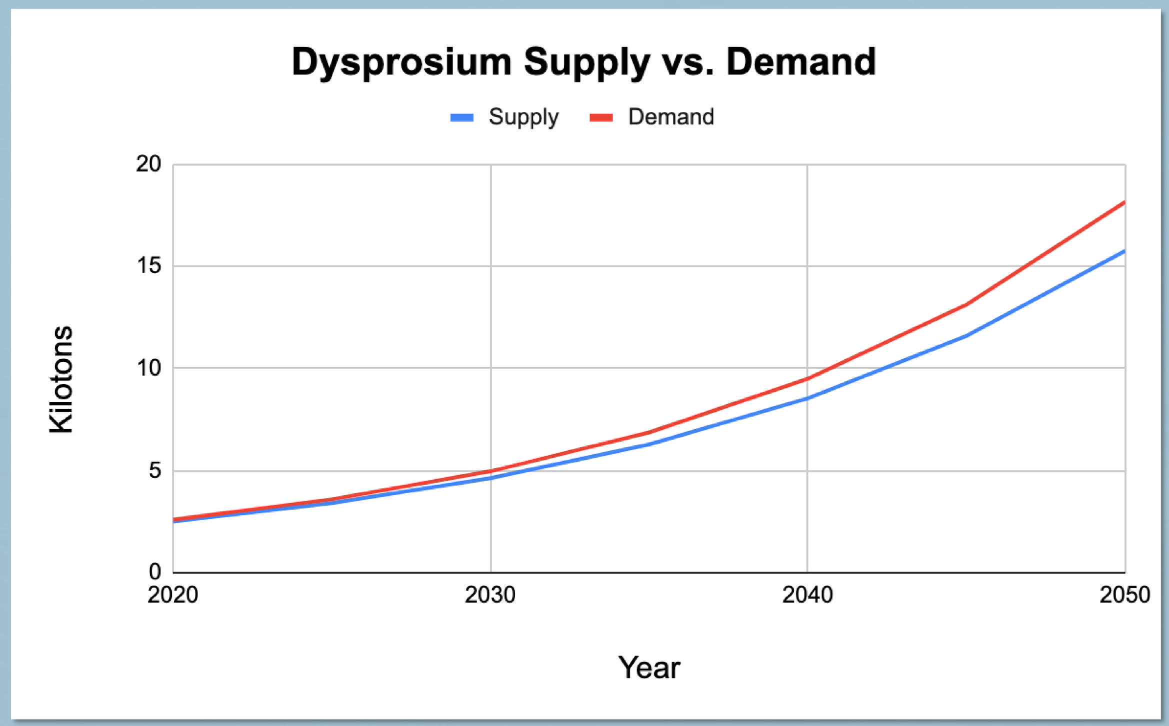


Figure 3: Projected Dysprosium Supply vs. Demand through 2020 - 2050

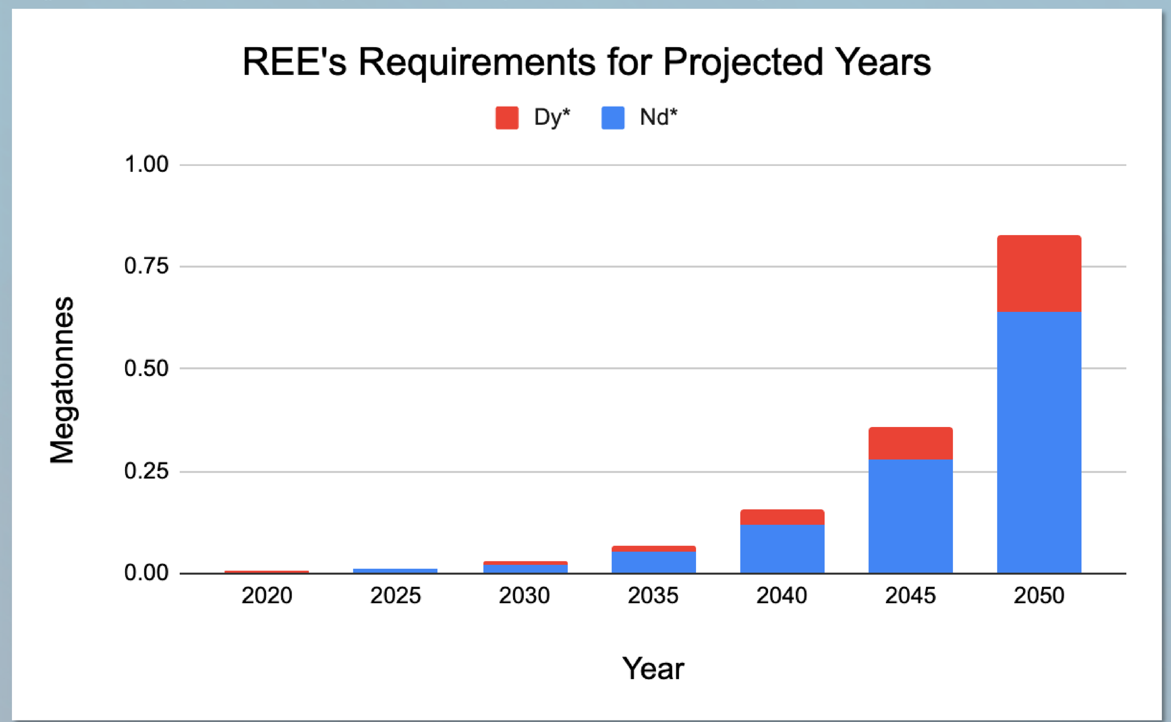


Figure 4: Projected Rare Element Requirements for 2020 - 2050

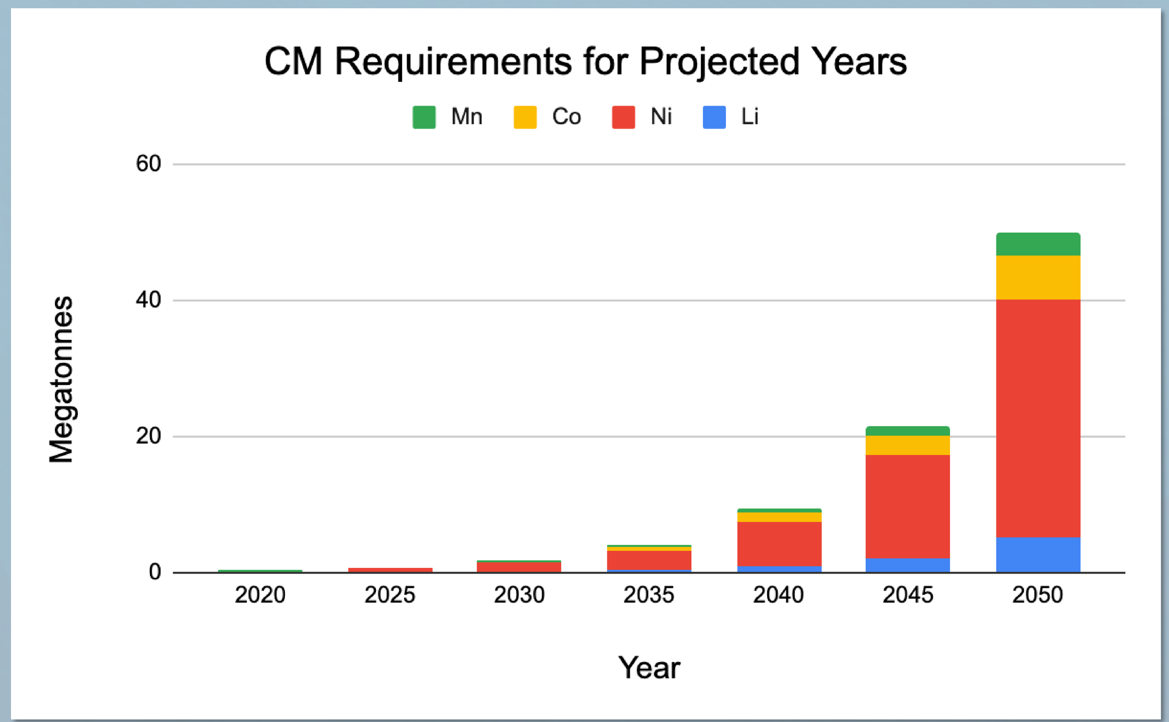


Figure 5: Projected Critical Mineral Requirements for 202 - 2050

Conclusions

- Traction motors based on NdFeB magnets will impose a substantial demand upon projected Dy production, but not Nd in coming years.
- Even with an aggressive EV adoption rate of 18.2 % (based on Bloomberg NEF), the Li supply appears adequate for the Li-ion batteries.
- A shortfall of Ni is projected in 2045.
- Shortfalls of Mn are projected starting already in 2025, becoming dramatically larger by 2050.

Broader Implications

- The annual demand for global REEs reached 240,000t in 2021 and is projected to reach 315,000t in 2030.
- In 2021, China accounted for 85% of the global supply of refined REEs, followed by the rest of Asia at 13% and Europe at 2%, according to Roskill.
- China has a more than 90% share of the global production of downstream rare earth products and technologies, including magnets.
- Adamas Intelligence forecasts that the value of global magnet rare earth oxide consumption will triple from $15.1bn in 2022 to $46.2bn by 2035.
- The United States was 100 percent import dependent for 17 minerals, and over 50 percent reliant for another 30 minerals in 2021. The value of non-fuel minerals produced in the United States in 2021 was an estimated $90.4 billion, with domestically processed mineral materials worth an estimated $820 billion. In turn, these materials were used by downstream industries to contribute roughly $3.32 trillion to the U.S. economy.

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Acknowledgements

- Support through the EME Summer Internship Program is gratefully acknowledged.

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