

**Energy transition: Market Demand of Lithium Ion Batteries and its Sustainability in India****N. Atri Assistant Professor, Dept. of Economics, SGNDKC, University of Delhi****Abstract**

In COP 21 (2015), 196 countries signed the Paris agreement for boosting clean energy and its transition with battery storage capacity. After that world has witnessed the emerging demand for critical minerals which will be required to make this energy transition possible through their products. When it comes to India, it made the commitment in COP26 held in 2021 to decrease the emissions to zero level by 2070 and for this a climate action strategy is being made. With green technology the other challenges are being associated and one of them is availability of critical minerals in India. In case of Lithium Ion batteries India is largely dependent on imports. With emerging automotive market of electronic vehicles Lithium ion batteries are in huge demand. According to Central Electricity Authority 136 GW is required to add 450 GW renewable energy sources by 2030 in the country, which will make India a large consumer of Li-Ion batteries. Earlier the demand of Lithium ion batteries in India was derived from portable items like mobiles, laptops, headphones and other electronic items. It accounted only 20 percent of LIB demand while 80 percent demand will be from EVs. According to the report of Institute of Energy Economics and Financial analysis estimates that the annual capacity of Lithium ion Batteries for electronic vehicles will hype from 2.36 GW in 2021 to 104 GW by 2030. For others like (data centres, telecom towers, and grid-scale renewable energy (RE) integration and rooftop solar (RTS)), it will be hyped from .3 GW to 12 GW. The central Government policy FAME Faster adoption and Manufacturing of Hybrid & EV backed the latest automotive application which will further hype the demand of Lithium ion batteries by 90 percent. So with the upsurge demand of Lithium ion batteries, it is challenge as well as an opportunity for India to extract it from recycling and reduce the e-waste burden on India. This paper will study the possibilities to face this challenge and in this light will suggest appropriate measures

**Keywords:** Lithium ion, Emissions, Recycling, energy Renewal, waste

**Introduction**

In COP 21 (2015), 196 countries signed the Paris agreement for boosting clean energy and its transition with battery storage capacity. After that world has witnessed the emerging demand for critical minerals which will be required to make this energy transition possible through their products. When it comes to India, it made the commitment in COP26 held in 2021 to decrease the emissions to zero level by 2070 and for this a climate action strategy is being made. With green technology the other challenges are being associated and one of them is availability of critical minerals in India. In case of Lithium Ion batteries India is largely dependent on imports. With emerging automotive market of electronic vehicles Lithium ion batteries are in huge demand. According to Central Electricity Authority 136 GW is required to add 450 GW renewable energy sources by 2030 in the country, which will make India a large consumer of Li-Ion batteries. Earlier the demand of Lithium ion batteries in India was derived from portable items like mobiles, laptops, headphones and other electronic items. It accounted only 20 percent of LIB demand while 80 percent demand will be from EVs. According to the report of Institute of Energy Economics and Financial analysis estimates that the annual capacity of Lithium ion Batteries for electronic vehicles will hype from 2.36 GW in 2021 to 104 GW by 2030. For others like (data centres, telecom towers, and grid-scale renewable energy (RE) integration and rooftop solar (RTS)), it will be hyped from .3 GW to 12 GW. The central Government policy FAME Faster adoption and Manufacturing of Hybrid & EV backed the latest automotive application which will further hype the demand of Lithium ion batteries by 90 percent. So with the upsurge demand of Lithium ion batteries, it is challenge as well as an opportunity for India to extract it from recycling and reduce the e-waste burden on India.

**Literature review**

*World Bank, 2004*, India is second most populous country with over 1 Billion people in the world. According to *D. Sinha et al*, It has larger market in absolute terms than that of developed countries. The demand of the durable items and pc is increasing with years.

*Euromonitor, 2004* noted that the demand of the personal computers increased to 604 percent from 1993 to 2000 even above the world average of 181 percent. It resulted in the increase of the PCs number approximately from 4 lakh to 4 crore. But it did not match with the environmental protection. The rank of India in Environmental sustainability index was 101th in 2005 (Esty, et al).

With economic growth it has been noticed that the awareness of the manufacturers and consumers especially regarding environmental concerns did not go with pace of the development. Though the government had passed many regulations regarding environmental protection the concerns for environment always took the back seat. The Indian market for the electrical products has a chain of first, second and third users depending upon the income (*Haque et al, 2000*).

*A report of a NGO, Toxics Link, New Delhi in 2004* reported that the household and business in India make 1.38 million approximately number of personal computers. The recycling of the computers is happening in the unorganised market and because of the useful life the vintage computer is going to the recycling. E waste situation in India according to the same report is grave and it comes under the Hazardous Waste Management and Handling Rules 1989.

*Empa 2004*, mentioned that the recycling of e- Waste has become popular among the unorganised sector who do the recycling due to profit only and not because of the environmental concerns. The work of recycling is flourished as the backyard workshops. Even after the upsurge in the demand of electronic items the recycling capacity did not grow and the hazardous way of recycling continued with no knowledge of data of unorganised units involved in the recycling work.

The report of Mumbai Based NGO WRA 2022, mentioned that with time the battery based waste has increased and are found being dumped in the household waste. There was no way of collecting the dry celles and pencil cells which are Lead acid based. Even the Muncipal Waste rules does not include batteries as hazardous waste. It also mentioned that millions of batteries which are generated annually don't have any scientific method for recycling and usually it is found in refill which is leaching out in the environment

According to IEEE Spectrum the Li ion batteries are being used from 1991 in mobile phones and other gadgets but after 2019 The Nobel prize winners of Chemistry revolutionized the battery with more addition of life cycles to it.

A report of NITI Aayog submitted on '*Enhancing material efficiency and recycling: Strengthening the circular economy*', to the secretarial of UNFCCC in 2022 where long term low emissions development strategy has been made and target of net zero emission by 2070 is being made. Niti Ayog in the same report estimated the new batteries potential in India especially after policies for use of Electric vehicles. According to the report the EVs influx in automotive and non auto-motive renewal energy setups will increase the demand for lithium ion batteries in future with double fold rate. According to National Institution for Transforming India (NITI) Aayog assessments, fresh batteries would produce a recycling capacity of 128 GWh by 2030, of which about 46 percent will derive from Electric Vehicles. To delight this capacity, India's lithium battery recycling capacity would need an increase about 60 times over the following eight years, from the current level of 2 GWh

*Times of India 2023* in an article says that In India reusing the batteries will increase the life span and the recycling of lithium ion batteries will ensure some local availability of the critical minerals, which will subsequently reduce the pressure of mining and imports. This will support decrease the carbon footprint as well as greenhouse gas (GHG) emissions.

The report on “*Recycling of Battery material towards material security and sustainability*”, CSE 2022, reported that LIB manufacturing is the lucrative opportunity for the battery back producers as well as solar stationary and electronic vehicle players. It also mentioned that at present the R&D is more or less diverted towards the manufacturing of the batteries rather than recycling. The reuse of battery is still underestimated as India targets to be carbon neutral by 2070. If we take the concept of circular economy the recycling become the crucial component. However it is a challenge to opt for full scale reuse and recycling. Globally the different policies and regulations create the landscape for India to make the sustainable policy for the recycling of Lithium ion batteries. At present the recycling of Lithium ion batteries is largely done by unorganized sectors which suffers from the health hazards. It is no doubt that at present India needs a robust formal sector in recycling (Hanicke et al. 2023). Presently, Lithium Ion batteries account for 51 percent of the total LI- battery market. The global demand of 700 GWh in 2022 is anticipated an upsurge till 4.7 GWh by 2030. During the same period, India’s demand of 3.9 GWh in 2022 is expected to rise to 116 GWh (Gulia et al. 2022). According to an International Energy Agency (IEA) report “*The Role of Critical Minerals in Clean Energy Transitions 2022*,” the demand for essential seven minerals for low-carbon technologies is projected to increase significantly. Electronic vehicles share in the economy is presently at the level of 35 percent and it will reach to 90 percent by 2030. So the demand for the critical mineral as Lithium will increase. Stringent regulations concerning the discarding of batteries need to be enacted in order to give incentive to the Li-ion battery recycling industry. As the capacity of battery manufacturing raises, a parallel system of disposal and recycling will be essential to minimize the detrimental impact on the environment. Theoretically, all the metal elements used in a Li-ion battery namely Li, Co, Ni, Mn, Co, and Al could be extracted and re-used for either battery or other applications.

### Research Gap

Identifying the gap, the various reports and literature had already talked about the up-surging demand of the Lithium Batteries and the need of the recycling and reuse as a circular economy. Some research papers talked about the model for recycling present in Switzerland with bit comparison of Indian setting and tentative model which can work in it.

Till now we have studies which estimated the expected demand raise till 2030 and suggested that recycling is an unavoidable requisite. But since 1990 till now many other products have come in the market. New product is Electric vehicle use which is a part of zero emission strategy of India by 2070. It will give a sharp hike to the demand. The gap in research in lithium ion batteries recycling reflects the unavailability of clear understanding of the existing market as it is comprised of organised and unorganized. The questions regarding the life span especially in Indian case where we have repair economy and third user existence, suitable models in Indian setting, informal sector existence in Lithium ion batteries, the specific health hazards from extracting Lithium from unscientific methods, the exact percentage of the informal sector, lack of knowledge regarding the recycling chain in informal sector and finally a strong legislative and policy recommendation are not found in the literature. However the concern has grown but still there is a need of understanding this area of research.

### Objectives of study

- To understand the various factors which are determining the crucial demand of Lithium ion batteries
- To suggest some policy and ground based measures.

### Research Questions

- What are the determinants which makes Lithium ion batteries recycling crucial?
- What could be the possible solutions for existing challenges in the field?

### Methodology and data 150

#### Hypothesis

The hypothesis for this paper will be based on the inductive research method based on Ground theory where you don’t have to go for the preconceived hypothesis

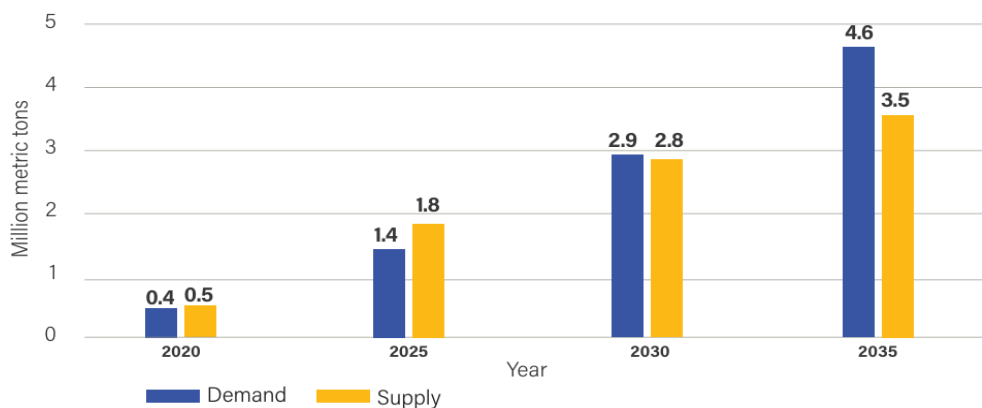
Grounded theory is a research method that involves developing theories from data, without starting with a specific hypothesis about the outcome and validating it later. Instead in this approach the data collection guide the analysis and theory creation. It is qualitative in nature which slows you to study the particular phenomenon and discover solutions or theories on the basis of real word data.

#### Data Collection

Secondary source will be used for the data collection in this study. Several reports related to e waste and Lithium ion battery recycling will be studied. The Government reports (NITI Ayog report, Central Electrical Authority report) and environment Sustainability reports will be considered. The research by different NGOs and institutes will also be considered.

### Findings

As we know that the demand for energy storage is increasing, it is leading the demand for critical elements for energy storage. The image below is showing the global demand and supply for lithium and it clearly shows that we will reach on threshold in 2030. Then 2030 onwards the demand for Lithium ion Batteries will be higher and supply constraints will increase.



Sources: Wurzbacher et al. 2022.

Figure 1: Lithium ion battery demand and supply globally

If we see demand for critical minerals in India Including Lithium, It has a clear cut increase from 31 percent in 2017 to 56 percent in 2022. With zero emissions target and upsurge of EVs in India the demand will definitely have a sharp hype.

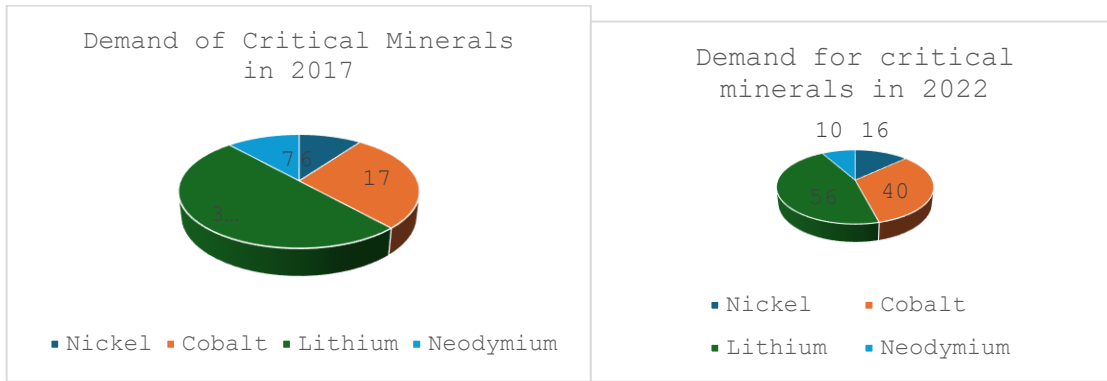


Figure 2: Source of Data : CEA report 2023

As for Lithium we are dependent on mining globally. Australia has maximum Lithium mines. In India we don't find Lithium and are mostly dependent on imports from China and that is around 75 percent. According to Dominish 2021 the critical metal mining will reduce by 2040 where Lithium will be reduced till 25 percent

The new upsurge demand of Electric Vehicles in past five years is observed and new global companies are venturing in India. However if we see the cost of EVs isn't that affordable. It is observed that from 2017-18 to 2023-24 the EV vehicle demand of E2. E3. E4 and EV buses categories increased drastically.(Table1)

Table 1: Electric Vehicle Sales – Dashboard								
Category	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Grand Total
E-2 Wheelers	2,005	28,007	26,834	44,803	2,52,642	7,28,054	9,44,126	20,26,471
E-3 Wheelers	91,970	1,16,031	1,43,051	90,898	1,72,543	4,01,882	6,32,485	16,48,860
E-4 Wheelers	1,204	1,885	2,377	5,154	18,622	47,499	90,432	1,67,173
E-Buses	19	66	434	373	1,194	1,984	3,693	7,763
<b>Grand Total</b>	<b>95,198</b>	<b>1,45,989</b>	<b>1,72,696</b>	<b>1,41,228</b>	<b>4,45,001</b>	<b>11,79,419</b>	<b>16,70,736</b>	<b>38,50,267</b>

If we look at the targets of India towards sustainability, it raises the more concern for Lithium availability for the long term and its recycling become more critical to extract some of Lithium from the e waste. As the renewable energy sources will require energy storage and Lithium ion batteries will be the best solution till any other technological development.

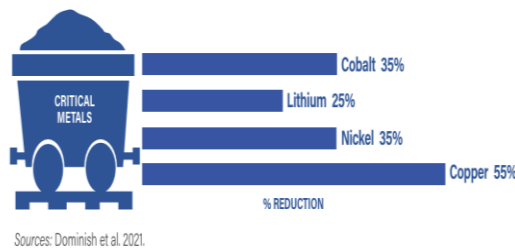


Figure 3: Reduction in critical Metal Mining due to recycling by 2040

Element	Climate Action Target		Status	
	Goal	Year	Current	Year
Reach 500 GW of non-fossil energy capacity by 2030	500 GW	2030	198.8 GW	March 2024
50% of electricity requirements will be from renewable electricity by 2030	50%	2030	24.9%	2021-22
Reduction of total projected carbon emissions by one billion tonnes from 2021 to 2030	1 billion tonnes reduction	2030	N/A	N/A
Reduction of the carbon intensity of the economy by 45% by 2030 over 2005 levels	45%	2030	33%	2019
Achieving the target of net zero emissions by 2070	Net zero	2070	26,46,556 Gg of CO <sub>2e</sub>	2019

Source: (Central Electricity Authority, 2023c), (Central Electricity Authority, 2023a), (PIB, 2023c), (Ministry of Environment, Forest and Climate Change, 2023).

Table 2: Government of India's Climate Action Plan

The above shown climate change targets motivates the public to use Electric Vehicles so the emissions from petrol and diesel based vehicles can be minimised.

To achieve this India has already launched FAME Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicle (FAME) Scheme in April 2015 for the promotion of Electric Vehicles in India. Which with other electronic items already hiked the Lithium ion batteries demand by gross 80.65 percent in five years. (Figure 2). And a sharp increase of gross 94.30 percent in the sales of electric Vehicles over the years is evident through figure 5.

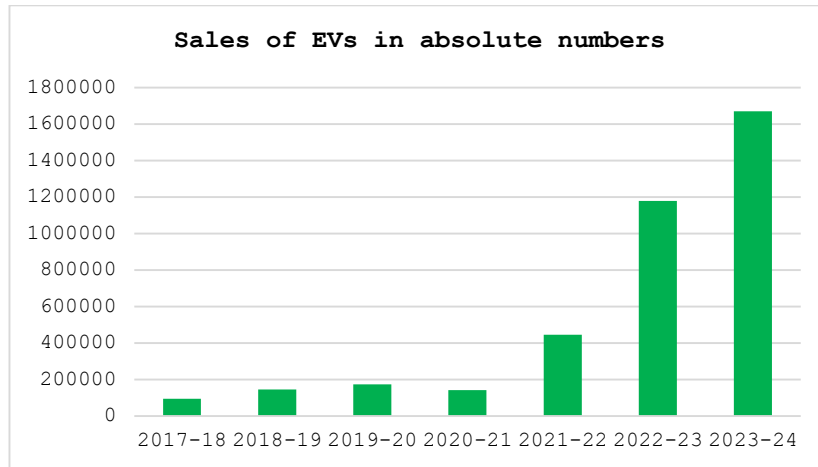


Figure 4 Source : SMEV (Society for Manufacturers of EVs)

So as the sales of EVs increased so the Import of Lithium. If from the below table we try to find out the correlation of Lithium Import and EV sales, It comes positive and significant.

Year	India Total Import	Electric Vehicle Sales
2023-2024	561,604,236.63	1,670,736
2022-2023	574,980,127.11	1,179,419
2021-2022	457,277,458.91	445,001
2020-2021	291,595,770.04	141,228
2019-2020	336,095,445.61	172,696
2018-2019	359,467,461.19	145,989
2017-2018	300,103,343.35	95,198

Table 3 Imports of lithium and EV sales

**Statistics findings**

- Strong Positive Correlation ( $r = 0.92$ )
- 85% EV sales variation explained by imports ( $R^2 = 0.85$ )
- EV CAGR: 61.21%
- Import CAGR: 11.01%
- Growth is highly battery-import dependent
- Strong case for domestic cell manufacturing acceleration
- Pearson Correlation ( $r$ ): 0.9227
- Coefficient of Determination ( $R^2$ ): 0.8515
- **Regression Equation:**
- $EV\ Sales = 0.004801 \times Import - 1426129.30$

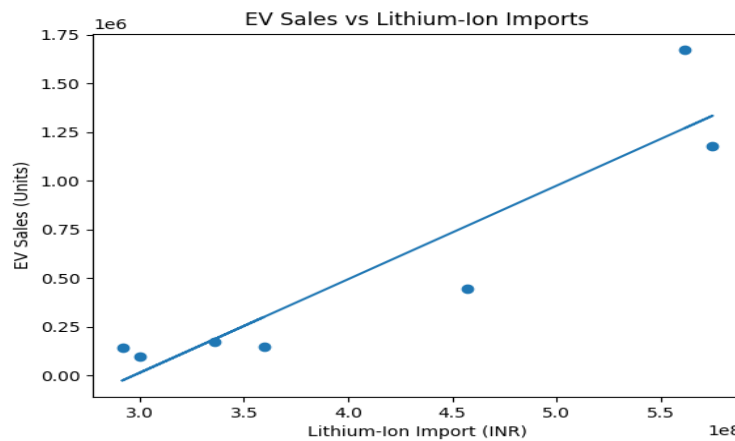


Figure 5: Positive correlation between Lithium Ion import and Sales of EVs

The projector of the growth of EV sales is shown in Figure no 8. This in addition to, above correlation, shows that the future Lithium ion demand will increase too. And the fact is one EV sale battery has its cycles and it needs to be replaced by the new batteries so this figure is a lesser picture of just new vehicles. However the new batteries for old vehicle data still needs to be considered.

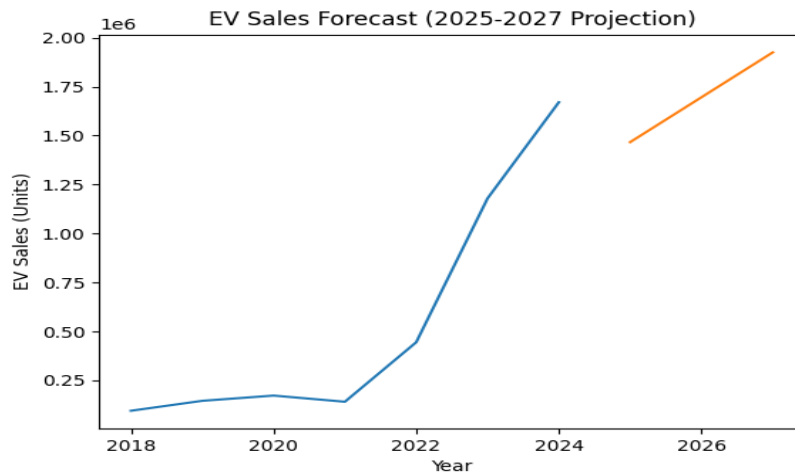


Figure 6: EV sales forecast

With this demand increase government had already incentivised the producers to add the annual capacity of Lithium from 2.3 GW to 104 GW by 2030 for locomotives and .3GW to 12 GW for non-automotives.

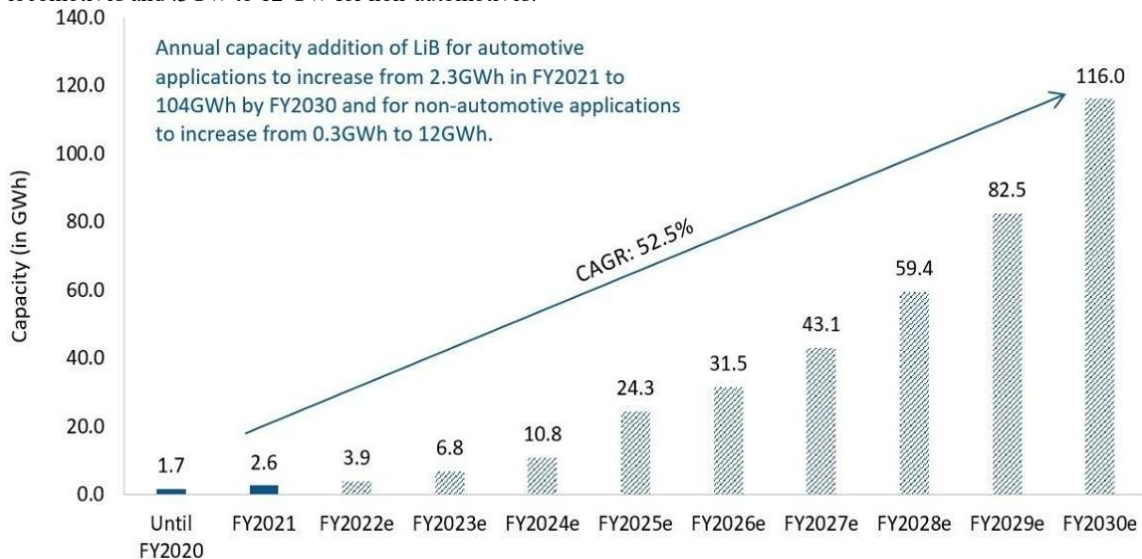


Figure 6: LIB Annual Additions in India  
 Source: CSEP working paper 2024

The annual requirements for manufacturing BESS (Battery Energy Storage System) for India’s grid in the base case situations are provided in Table 4, along with the projected capacity addition in GWh. The demand for battery minerals for India’s battery storage is anticipated to increase ominously in both the base and disruptive cases, reflecting the short-term supplies for energy storage in the grid. As with solar and wind, there would need to be a sharp increase in mineral demand around 2030 to meet intermediate climate targets.

Mineral	2025	2026	2027	2030	2032	2037	2042	2047
Lithium	58	174	517	13,671	2,771	9,401	11,878	20,845
Cobalt	17	49	147	3,878	786	2,667	3,370	5,914
Nickel	52	155	461	12,198	2,473	8,388	10,598	18,599
Manganese	20	61	181	4,797	972	3,298	4,167	7,314
Graphite	609	1,814	5,405	1,42,892	28,966	98,259	1,24,153	2,17,884
Copper	240	714	2,128	95,588	11,404	38,684	48,878	85,779
Vanadium	43	129	384	56,255	2,060	6,988	8,830	15,496
GWh Addition	1	2	5	138	28	95	120	211

Table 4 BSES Mineral increase in GW addition Source CSEP 2024

**Conclusion and policy implications**

The demand potential of LIBs in India is high and continuously growing. As the critical minerals involved are unavailable in India. On the other hand research and development investment in cell technology is limited in India and large scale investments are also inadequate. Another

important concern is geo political tension with China, which also pose a threat to the supply chain as 75 percent of lithium batteries are imported from China. It makes India's electric vehicle industry more vulnerable due to possible uncertainties and risks.



So the suggestion will be reuse and recycling which is not merely a concept but globally companies are engaged in reuse and recycling. The second life batteries are expected to hold more than 200GW by 2030. Rest of the requirement gap can be fulfilled by the technology development which has its own gestation period. However investments in R&D of reduced mineral requirement battery may change the whole scenario of the market.

Another recommendation will be investing in recycling units so the extraction of minerals can be done. This paper identify the challenges ahead where policy makers should focus their attention to understand the magnitude of the problem which may arrive if there is a disruption in supply chain of LIBs. The policymakers should be ready for the supply bottlenecks in the future in case of supply of value chain disruption and future sustainability.

The key points of Recommendations are as follows

There should be increased investment in R&D of improving the technology of LIBs, in untapped mining and recycling of the critical minerals.

To increase the recycling of the batteries some pilot studies should be done to understand the consumer behaviour and market.

There should be a huge investment in organised critical mineral recycling units.

The unorganised sector too should be brought in the realm of formalisation and scientific methods should be adopted for the recycling. This will further help in combating the health hazards of people engaged in unorganised sector and saving landfills and environment.

An appropriate policy outline would streamline the process of battery collections and segregations as well as stop recycling in the unorganized sector where suitable safety considerations are often ignored.

Incentivise private sector in above ventures should be done.

The consumer and producer awareness with product stewardship for recycling of LIBs should be done through major awareness or education programmes. This will increase the collection rate and further will fetch the investment of private sectors

Last but not the least, research can be carried out on 'circular economy' by proper understanding of second and third life use of the battery in India.

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