IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Study On Critical Mineral Imports And India's Green Energy Transition

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Abstract

India, world's third-largest consumer of energy, is moving towards I a greener, sustainable energy landscape. Global climate obligations, lower dependency on fossil fuels, and the need to enhance energy security are the primary reasons for this shift. Green energy transition depends on critical minerals - key raw materials essential for the development of renewable energy technologies. Solar panels, wind turbines, electric vehicles (EVs) and energy storage systems use critical minerals. Over the past few decades, China has been the dominant country, exporting 60-70% of critical minerals to the world. This has made the world heavily dependent on China for critical minerals. To reduce dependency and aid the global supply chain, India has begun exploring these critical minerals to meet domestic and global demand as the world transitions to green energy.

Key words: Critical Minerals, Imports, Indian Economy and Green Energy.

1. Introduction:

Critical minerals are those minerals that are essential for economic development and national security. The lack of availability of these minerals or concentration of extraction or processing in a few geographical locations may lead to supply chain vulnerabilities and even disruption of supplies. The future global economy will be underpinned by technologies that depend on minerals such as lithium, graphite, cobalt, titanium, and rare earth elements. These are essential for the advancement of many sectors, including high-tech electronics, telecommunications, transport, and defence. They are also vital to power the global transition to a low carbon emissions economy, and the renewable energy technologies that will be required to meet the 'Net Zero' commitments of an increasing number of countries around the world. Hence, it has become imperative to identify and develop value chains for the minerals which are critical to our country.

The Ministry of Mines accordingly constituted a seven-member Committee under the chairmanship of Joint Secretary (Policy), Ministry of Mines vide order No. 11/1/2022-IC dated 01.11.2022 to identify the list of minerals critical to our country. The Committee had a series of deliberations amongest the members and decided to have a three-stage assessment to arrive at a list of critical minerals. The first stage of assessment was to study the critical minerals strategies of various countries to determine the parameters for assessing criticality and come up with a set of minerals for identification as critical minerals.

Accordingly, a total of 69 elements / minerals that were considered critical by major global economies such as Australia, USA, Canada, UK, Japan and South Korea were considered for study. Due importance was given to domestic initiatives also. The key studies carried out in this aspect are by Centre for Social and Economic Progress (CSEP)- a not-for-profit, public policy think tank and Council on Energy, Environment and Water (CEEW)- an independent, non-partisan, not-for-profit policy research institution.

In the second stage of assessment, an inter ministerial consultation was carried out to identify minerals critical to the sectors concerned. A meeting was held with representatives from the Ministry of Power (Central Electricity Authority), Department of Atomic Energy (DAE), Ministry of New and Renewable Energy (MNRE), Ministry of Chemicals & Fertilizers (Department of Fertilizers), Ministry of Electronics & Information Technology (MEiTY) and IREL (India) Limited. Comments and suggestions were received from the Ministry of Power, Department of Atomic Energy, Ministry of New and Renewable Energy, Department of Fertilizers, Department of Science and Technology, Department of Pharmaceuticals, and NITI Aayog for sharing the list of minerals which are critical to their respective sectors. Thus, a list of minerals critical for different sectors, based on inter ministerial consultation was arrived at.

The third stage assessment was to derive an empirical formula for identifying the list of critical minerals. In order to derive the criticality index, a meeting was held with International Energy Agency (IEA). The Ministry of Mines also had a series of deliberations with CSEP, who have adopted the EU methodology to arrive at a list of critical minerals. The EU methodology, considers two major factors - economic importance and supply risk. The formula covered crucial parameters such as disruption

potential, substitutability, cross cutting usages across different sectors, import reliance, recycling rates etc. However, it was observed that minerals like limestone, iron ore and bauxite also came out as critical as per the factors considered in the formula used by CSEP. The Committee is of the view that a detailed statistical exercise needs to be carried out for precise computation of various factors such as sustainability index, minerals cross-cutting index, import reliance etc. Hence if felt necessary, a separate sub-committee may be constituted by Ministry of Mines to exclusively work out the formula to develop the criticality index. In the present exercise, the Committee has compared the list of critical minerals derived by CSEP (based on EU methodology) with its own set of minerals derived after going through the two-stage assessment process mentioned above. Accordingly, the elements/ minerals with high Economic Importance, high Supply Risk, and both parameters high were selected as critical by the Committee.

Based on the three-stage assessment process mentioned above and also considering important parameters such as resource/ reserve position in the country, production, import dependency, use for future technology/ clean energy, requirement of fertilizer minerals in an agrarian economy, the Committee has identified a set of 30 critical minerals. These are Antimony, Beryllium, Bismuth, Cobalt, Copper, Gallium, Germanium, Graphite, Hafnium, Indium, Lithium, Molybdenum, Niobium, Nickel, PGE, Phosphorous, Potash, REE, Rhenium, Silicon, Strontium, Tantalum, Tellurium, Tin, Titanium, Tungsten, Vanadium, Zirconium, Selenium and Cadmium. The Committee also recommends creation of a Centre of Excellence for Critical Minerals (CECM) in the Ministry of Mines. The Centre of Excellence will periodically update the list of critical minerals for India and notify the critical mineral strategy from time to time and will execute a range of functions for the development of an effective value chain of critical minerals in the country.

2. Objectives of the Study:

To understand the importance of critical minerals in the present context.

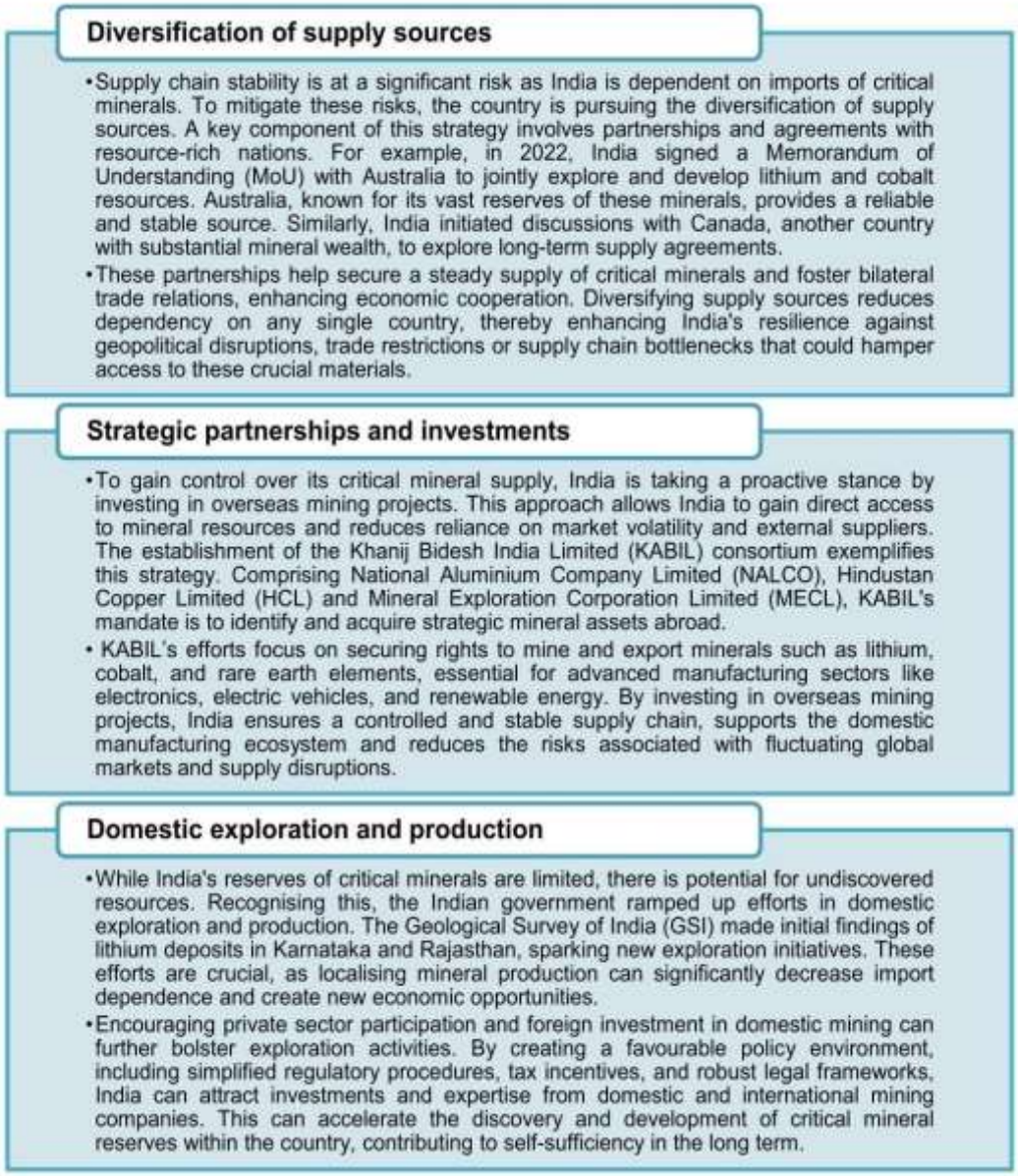
To study the India's Energy Evolution and a shift towards renewable energy.

To examine the total volume of imports and exports of minerals.

3. Theoretical Frame work:

3.1 The Importance of Critical Minerals

Modern technology is built mostly by using critical minerals. Critical minerals are needed to build solar panels, advanced batteries for storage and transportation, semiconductors, and wind turbines. There cannot be energy transition without critical minerals. However, there are challenges that these critical elements face which include, supply disruptions due to shortage, inadequate production, and geopolitical factors. Lithium-ion batteries, permanent magnets, photovoltaic cells and electronic components that power green technologies are manufactured with the help of critical minerals. The use of critical minerals in various energy transition initiatives are described below:



- **Solar Energy:** Critical minerals such as silicon, tellurium, indium, and gallium are needed to produce photovoltaic cells used in solar panels. India's current solar capacity is 64 GW which is heavily dependent on these materials.
- **Wind Energy:** Rare earth mineralslike dysprosium and neodymium are important for permanent magnets used in wind turbines. India is dependent on the availability of critical minerals as it aims to expand its wind energy capacity from the current 42 GW to 140 GW by 2030.
- **Electric Vehicles (Evs):** Lithium, nickel, and cobalt are used in lithiumion batteries that power EVs. National Electric Mobility Mission Plan (NEMMP) aims to deploy 6-7 million EVs by 2024, implying more of these minerals will be required.
- **Energy Storage:** Nickel, cobalt and lithium are used in advanced energy storage solutions as they are dependent on lithium-ion batteries.

3.2 Strategic Measures Taken By India

India's strategic approach to securing critical mineral supplies is multifaceted, involving international partnerships, domestic exploration, recycling, and technological innovation.

3.3 Government Initiatives

National Mineral Policy 2019 The blueprint for mineral development in the country that has been outlined in the National Mineral Policy (NMP), 2019 has placed high importance towards critical minerals. The NMP 2019 aims to increase geological studies and mining through modern technology which includes, geospatial and geochemical survey together with remote sensing and three-dimensional subsurface explorations for mineral deposits. In promoting mining technologies, the NMP not only aims at advancing the operations of mines but also enhancing the level of safety, and environmental management of mining practices. The policy similarly pays attention to the social sustainability of mining by promoting activities such as mine decommissioning, land and waste engineering and land rehabilitation. In addition, NMP 2019 encourages active cooperation on the international level to implement the strategy in the field of critical minerals supply, seeking alliances, contracts, and joint activities with and efficient transportation of critical minerals regardless of adverse political situations.

3.4. Critical Minerals Strategy

In light of the significance placed on critical minerals for high-tech industries, renewable energy resources and other strategic sectors, a comprehensive Critical Minerals Strategy is being prepared by the Indian government. This strategy shall state measures for sourcing the minerals from different countries instead of using one country by engaging in multi-country strategies. It will stress on how to aggressively pursue internal exploration, using modern geological survey methods to search for unexplored reserves within the country. The strategy will also seek to promote urban mining, recycling and other waste lessening technologies to reduce water and land resources utilization. India has the potential to develop a circular economy on critical minerals through appropriate investments in proper recycling technologies and setting up good collection and processing facilities. Enhancing waste management and recycling systems is also a priority for the strategy and will involve the use of cross institutional countries holding major mineral resources. The purpose of these partnerships is to ensure the flow of knowledge and modern technologies, approaches by combining various sectors such as education, private sector and the state. This would be done to create new materials, improve methods of material recovery, processing technologies and refine the techniques or methods of accessing minerals. Acquiring these resources, as well as partnership with multiple countries and private business, will be crucial to forward this strategy.

3.5. Atmanirbhar Bharat initiative

The Atmanirbhar Bharat (self-reliant India) initiative is a mix of many policies with the prime objective to reduce the dependence on other nations for a wide range of commodities by domestically enhancing the production capacity. The focus on critical minerals relates to the extraction, processing and mining of these minerals using domestic capabilities, hence, minimising the dependence on foreign

technology. Under this initiative, provisions are granted related to providing funding and other policy measures such as tax breaks and subsidies for the attraction of resources in the critical minerals industry. There are also plans to develop Special Economic Zones (SEZs) and other industrial clusters for critical minerals. Atmanirbhar Bharat helps in the supply chain issues for domestically manufactured products such as electronics, renewable energy, electric vehicles, thereby positioning India strategically in the world market. This combination of supply of minerals with the capacity to manufacture goods is necessary for the attainment of self sufficiency and expansion of the economy.

3.6. Khanij Bidesh India Limited (KABIL)

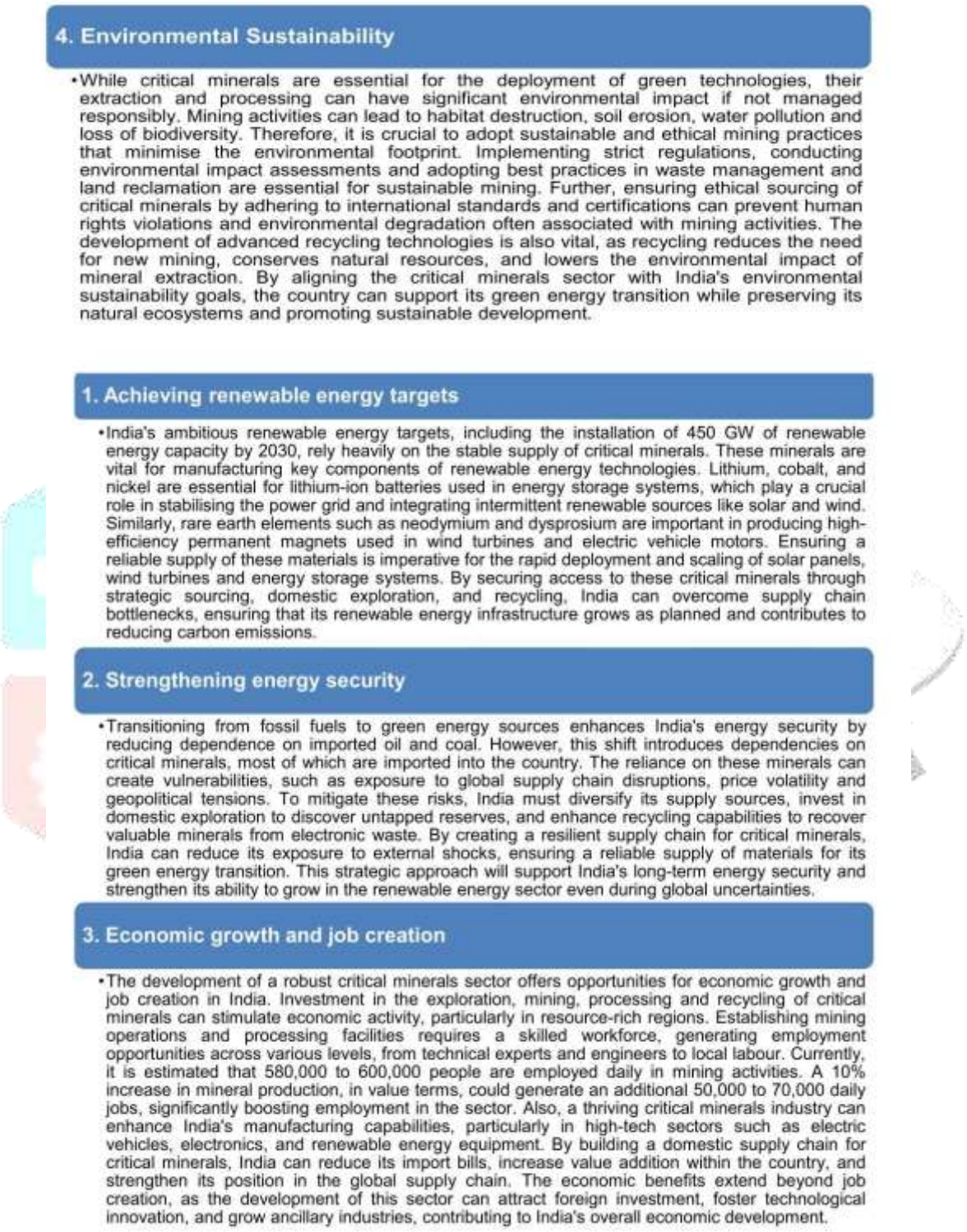
KABIL is an important initiative to develop critical mineral assets offshore. This Special Purpose Vehicle (SPV) was set up as a conglomerate of National Aluminium Company Limited (NALCO), Hindustan Copper Limited (HCL) and Mineral Exploration Corporation Limited (MECL), to explore and acquire foreign mining assets including lithium, cobalt, nickel, and other special minerals. KABIL's purpose is to obtain shares in offshore mining projects that will guarantee India a steady supply of the minerals and accordingly meet challenges posed by price fluctuations and supply shortages. KABIL promotes collaboration with foreign companies and governments by means of investments into joint projects and in long-term contracts, exploration, technology transfer and R&D to ensure a reliable supply of mineral resources. The general objective of the organization is to assist in the incorporation of critical minerals into the value chain of India which helps in industrial growth areas such as electric vehicles, renewable energy technologies and electronics. KABIL is also tasked to analyse the working of the purchased assets and organize transportation of the mined minerals to India to create a fully integrated value chain of mining as well as delivery.

3.7. Union Budget 2024-25

With an emphasis on the 'Manufacturing & Services' sector, as part of the Union Budget 2024-25, the 'Critical Mineral Mission' was established. This mission will aim to boost domestic production, recycling, and acquisition of critical mineral assets from abroad. Its goals will include advancing technology, developing a skilled workforce, implementing a producer responsibility framework, and setting up an appropriate financing system. It was also announced that there are plans to launch the first auction of offshore mineral mining blocks, building on the exploration work already done, with a focus on offshore mineral extraction.

3.8. GREEN ENERGY TRANSITION IMPACT

As India progresses from the use of traditional fossil fuel to renewable energy sources, the import of critical minerals is important. This transition is expected to have the following implications:



Due to geopolitical issues, trade limits, and natural disasters, the global supply chain for critical minerals is risk and therefore disruption of supply chain is very prominent. As India depends majorly on China for importing these critical minerals, the trade issues between the U.S. and China in 2019 highlighted the risks of China's dominance in this space. This presents the opportunity for India to be the upcoming destination for critical mineral hub with the help of domestic exploration. Both, the domestic demand for renewable energy generation as well as supply of these minerals to the western manufacturing industry,

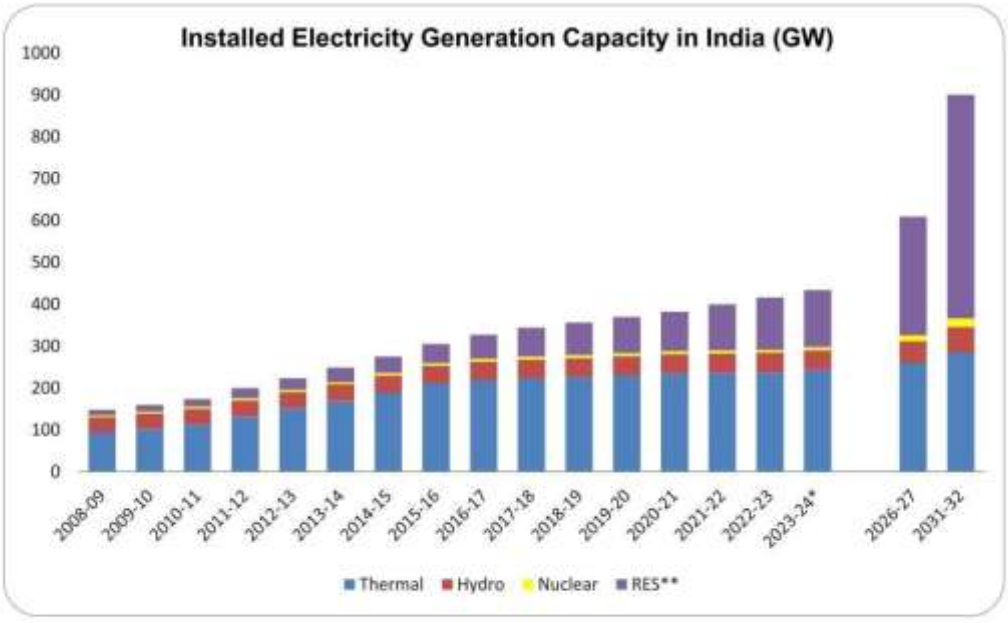
can be supported. Child labour and unsafe working conditions are some of the common issues that are faced while exploration of Cobalt, this causes ethical and environmental concerns. Mining activities have a major impact on the environment which is a significant challenge. India can navigate these concerns by putting in place policy frameworks which are focused on mitigating this challenge. The prices of critical minerals are dependent on supply issues, market demand, and trade. For example, the price of lithium rose from reached over US$ 15,000 per ton in 2024 from US$ 7,000 per ton in 2015. Such price volatility can affect the cost-effectiveness of green energy projects in India. With the help of domestic exploration, India can become self-reliant and be the price setter globally. India's emerging technological capabilities in the area of developing efficient extraction, processing, and recycling technologies for critical minerals, limits its ability to procure imported minerals domestically. This presents an opportunity for India to setup learning and skill development programs for the youth which in turn would lead to innovative solutions in this industry.

4. Results & Discussion:

4.1. INDIA'S ENERGY EVOLUTION: A SHIFT TOWARDS RENEWABLES

As of March 2024, the thermal power generation capacity accounted for 56% of installed electricity generation capacity in India, while renewable energy sources (RES) and hydroelectric power accounted for 32% and 11%, respectively. The contribution of nuclear power to the total installed capacity was only 2%.

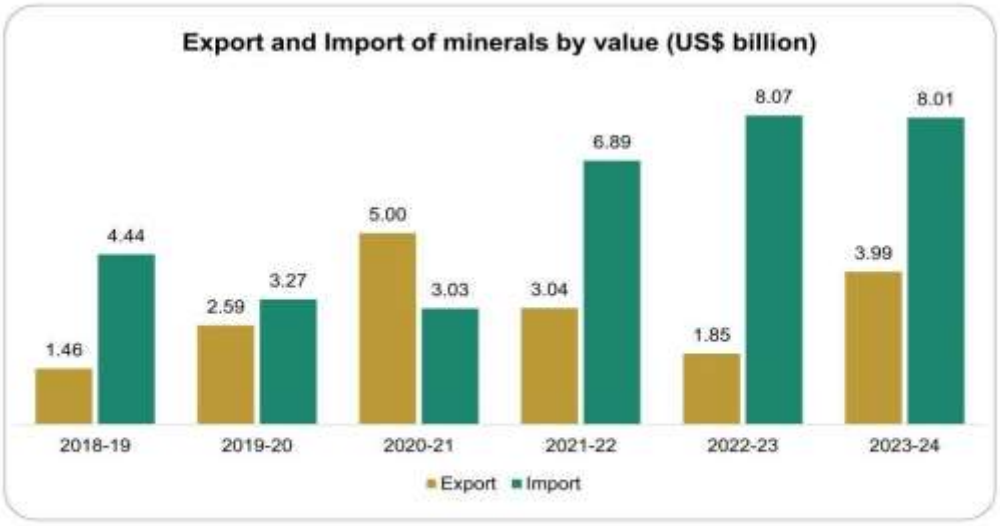
The proportion of thermal-based generation capacity in the overall installed capacity has seen a decrease from 63.3% in 2008-09 to 56% in 2023- 24. Simultaneously, the share of hydro-based generation capacity also diminished from 25% to 11%, while the capacity from renewable experienced a significant rise from 8.9% to 32%. From 2009 to 2023, CAGR of the total installed electricity generation capacity was approximately 7.7% in contrast to 17.4% for RES and 5.7% for all other sources.



Source: NEP 14, Annual Energy Statistics 2024, National Power Portal

*Data until March 2024, **- RES excluding large hydro projects

Energy sector in India is going through profound transformation, where it is progressively shifting away from fossil fuels and welcoming renewable energy sources. In 2022-23, the utility's installed capacity of RES (excluding hydro) grew by 12.20% while that of thermal sources grew by 0.49%. This trend demonstrates that India is changing its energy patterns with renewables accumulating more weight across the nation's electricity system. Within renewables, solar accounts for the biggest share in the pie of renewable energy at 53.4% followed by wind power (34.1%), bio-power and waste to energy (adding up to 8.2%), and small hydro projects (3.9%).



Source: Indian Bureau of Mines, Note: Figures are for all minerals excluding fuel/coal, gold/diamond and other minor minerals

As per the chart above, India's imports were on a downtrend between 2018-19 and 2020-21 as imports fell from US$ 4.44 billion in 2018-19 to US$ 3.03 billion in 2020-21. On the contrary, exports during the same period were on a rise. Exports of minerals grew from US$ 1.46 billion in 2018-19 to US$ 5.00 billion in 2020-21.

Post 2020-21, the trend reversed with imports increasing and exports declining. Export of critical minerals in 2020-21 was US$ 5.00 billion and decreased to US$ 3.99 billion in 2023-24. The COVID-19 pandemic and environment worry due to the exploration of critical minerals, were the reasons for this decline. However, the import of critical minerals during the same period have more than doubled. Imports reached US$ 8.01 billion in 2023-24 from US$ 3.03 billion in 2020- 21. The increasing use of renewable sources of energy is the primary reason for the rise in imports of minerals. Another driver is the heavy import of lithium as it is used in the batteries of EV vehicles.

4.2. Current import dependence:

As per the Ministry of Mines, India imported 80% of its lithium and cobalt requirement and 90% of its rare earth elements in 2023, to meet the growing demand for critical minerals. These large number of imports has helped to create international partnerships. Key partners include, Australia, Chile, the Democratic Republic of Congo (DRC) and China.

These collaborations help with the stable supply of essential minerals and promote global economic interdependence and cooperation. Below are a few key import partners for lithium, cobalt and other minerals:

Sr. No.	Critical Mineral	Percentage (2020)	Major Import Sources (2020)
1.	Lithium	100%	Chile, Russia, China, Ireland, Belgium
2.	Cobalt	100%	China, Belgium, Netherlands, US, Japan
3.	Nickel	100%	Sweden, China, Indonesia, Japan, Philippines
4.	Vanadium	100%	Kuwait, Germany, South Africa, Brazil, Thailand
5.	Niobium	100%	Brazil, Australia, Canada, South Africa, Indonesia
6.	Germanium	100%	China, South Africa, Australia, France, US
7.	Rhenium	100%	Russia, UK, Netherlands, South Africa, China
8.	Beryllium	100%	Russia, UK, Netherlands, South Africa, China
9.	Tantalum	100%	Australia, Indonesia, South Africa, Malaysia, US
10.	Strontium	100%	China, US, Russia, Estonia, Slovenia
11.	Zirconium(zircon)	80%	Australia, Indonesia, South Africa, Malaysia, US
12.	Graphite(natural)	60%	China, Madagascar, Mozambique, Vietnam, Tanzania
13.	Manganese	50%	South Africa, Gabon, Australia, Brazil, China
14.	Chromium	2.5%	South Africa, Mozambique, Oman, Switzerland, Turkey
15.	Silicon	<1%	China, Malaysia, Norway, Bhutan, Netherlands

Source: Ministry of Mines

Lithium: The new oil As climate change and global warming become more prominent, governments and businesses are setting ambitious goals to reduce carbon emissions to zero. To achieve these goals, it's essential to move away from energy sources that rely heavily on fossil fuels and switch to cleaner alternatives. Renewable energy technologies such as wind turbines, solar panels, electric vehicles (Evs), and energy storage systems are considered to be the preferred solution.

Lithium-ion batteries have become the preferred choice for EVs because they can store a lot of energy, recharge quickly, and last longer than other types of batteries. Lithium is considered to be more important than other minerals because it's flexible, easy to maintain, and used in many different applications, making it the most practical battery technology available today. In 2022, globally, more than 634,000 metric tons of lithium was produced. By 2030, it's expected that global lithium production will increase to over 2.14 million metric tons. However, the demand for lithium is expected to reach 3.1 million metric tons by 2030, which will create a significant shortage. In November 2023, India highlighted the importance of lithium by auctioning off critical mineral blocks, including a lithium block in Jammu and Kashmir. The finding of 5.9 million tons of lithium reserves in this area makes India the seventh-largest source of this critical mineral.

The main players in the global lithium supply chain are China, Australia, and the "lithium triangle" in South America, which includes Chile, Argentina, and Bolivia. Australia, with 6.2 million tons boasts of the third-largest lithium reserves in the world, and is also the second-largest producer, with a capacity of 61,000 metric tons. The lithium triangle supplies about 60% of the world's lithium needs.

In order to meet its lithium needs, India is majorly dependent on imports. It is the world's largest importer of processed lithium, mainly from China and Hong Kong. In the 2020-2021 period, India imported more than US$ 722.5 million worth of lithium. With China, Japan, and South Korea as the major exporters of lithium-ion batteries, India is one of the largest importers. In 2022, India imported 617 million lithium-ion batteries, valued at US$1.8 billion. India is keen on reducing its dependence on imports for strategic reasons. To address this, India approved a Production Linked Incentive (PLI) Scheme in May 2021 to encourage domestic manufacturing of Advanced Chemistry Cell (ACC) batteries. Although India is making rapid progress towards ensuring its future energy security, it will take about a decade to start commercially operating a lithium mine and even longer to establish a complete domestic supply chain for manufacturing lithiumion batteries. Despite these challenges, India has set ambitious goals, including reaching net-zero emissions by 2070, achieving a 30% share of EVs in new vehicle sales, and increasing its non-fossil fuel energy capacity to 500 GW by 2030. To meet these goals, India will need a significant amount of lithium and lithium-ion batteries. To secure this supply, India's Ministry of Mines created Khanij Bidesh India Limited (KABIL) to find, acquire, develop, and commercialize strategic minerals from overseas. In January 2024, KABIL signed a US$24 million agreement to explore lithium in five areas in Argentina, giving KABIL the exclusive rights to search for and develop lithium resources there.

5. Conclusion:

India's shift to green energy depends heavily on having access to critical minerals. As the country works to lower its carbon emissions and improve energy security, it's crucial to ensure a reliable supply of these essential minerals. The current global political landscape offers India a chance to benefit from more diverse supply chains. India's future economic success will depend on how effectively it uses its energy and mineral resources and adapts to the global move toward zero emissions. By taking a broad approach—diversifying sources, forming strategic partnerships, boosting domestic exploration, recycling, and investing in research and development—India can pave the way for a sustainable and resilient green energy future.

6. References:

1) https://www.ecgi.global/sites/default/files/working-papers/documents/greenenergydependsoncriticalmineralswhocontrolsthesupplychainsecgi.pdf.
2) Critical-Mineral-Imports-and-India's-Green-Energy-Transition%20(1).pdf
3) https://www.iea.org/reports/global-critical-minerals-outlook-2025
4) https://mines.gov.in/admin/download/649d4212cceb01688027666.pdf.
5) https://ieefa.org/sites/default/files/202410/India's%20Hunt%20for%20Critical%20Minerals.pdf