From Oil to Critical Mineral Dependence: Reassessing India's Energy Security in the Era of Global Energy Transition

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Abstract

India's energy security has traditionally focused on oil imports, price volatility, and instability in global fossil fuel markets, with crude oil dependence shaping its foreign policy, trade balance, inflation, and strategic planning. However, the global energy transition is redefining energy security. As electric vehicles, battery storage, solar and wind technologies expand, dependence on fossil fuels is increasingly being replaced by reliance on critical minerals such as lithium, cobalt, nickel, copper, graphite, and rare earth elements. Although renewable energy supports climate goals and reduces oil imports, it also creates new vulnerabilities because mineral supply chains are geographically concentrated, geopolitically sensitive, and environmentally contested. This paper examines how India's energy security framework must evolve from oil dependence to mineral security. It analyzes India's vulnerabilities, global competition for critical minerals, and policy options including domestic exploration, international partnerships, recycling, technological innovation and industrial policy. It argues that a diversified, long-term strategy is essential to ensure a secure, resilient, and sustainable energy transition.

Keywords

Energy Security, Critical Minerals, Energy Transition, Mineral Security, Supply Chain Resilience, Clean Energy Technologies, Geopolitics of India, Oil Dependence, Mineral Dependence, Global Energy Transition.

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Introduction

India's energy security has long been a major concern because the country depends heavily on imported energy to support its growing economy. For many years, oil has been at the center of this challenge, with rising import costs, price fluctuations, and geopolitical tensions affecting economic stability. To address these risks, India has focused on diversifying oil suppliers, maintaining strategic petroleum reserves, and strengthening maritime security. Today, the global energy system is changing. Countries are expanding renewable energy, promoting electric vehicles, and reducing dependence on fossil fuels to cut greenhouse gas emissions. For India, solar and wind power, battery storage, and electric mobility provide opportunities to reduce oil imports, improve air quality, create new industries, and meet climate goals. This transition is also changing the meaning of energy security beyond oil dependence.[1]

The clean energy transition does not remove dependence; it shifts it from oil to critical minerals such as lithium, cobalt, nickel, copper, graphite, and rare earth elements. These minerals are essential for batteries, electric vehicles, wind turbines, and power networks. However, their production and processing are concentrated in a few countries, creating new strategic vulnerabilities as global demand continues to rise.[2]

India's energy security must now go beyond oil and gas to include secure access to critical minerals, resilient supply chains, and technological capabilities. As critical minerals become essential for clean energy and advanced industries, India faces the challenge of avoiding a new form of strategic dependence. This transition requires reforms in mining, trade, diplomacy, manufacturing, recycling, and research to ensure long-term energy security. [3] This paper reassesses India's energy security in the era of the global energy transition. It argues that energy security must expand beyond fossil fuel dependence to include critical mineral security and resilient clean technology supply chains. The paper examines India's emerging vulnerabilities and proposes policy strategies for a secure and sustainable energy future.

Understanding Energy Security: Traditional and Emerging Dimensions

Energy security means having reliable and affordable energy for households, industries, and transport. Traditionally, it focused on ensuring a steady supply of oil, gas, and coal by reducing import risks, diversifying suppliers, maintaining strategic petroleum reserves, and protecting against global price shocks. While this approach remains important, the global energy transition is expanding the concept of energy security to include renewable energy technologies, infrastructure, and the critical minerals needed to support them.

As a result, the energy security in the twenty-first century includes the **five linked dimensions**:

- **Availability**: reliable access to fuels, minerals, and technologies.
- **Affordability**: stable and reasonable prices for energy systems and inputs.
- **Accessibility**: physical and institutional access to supply chains and infrastructure.
- **Sustainability**: environmental and social viability of extraction and energy use.
- **Resilience**: the ability to withstand disruptions, market shocks, or geopolitical pressure.

For India, this wider framework is especially important. The country must balance development, industrial growth, poverty reduction, climate action, and strategic autonomy. The transition to clean energy can strengthen long-term energy security, but only if India addresses the new risks created by mineral dependence and technology concentration. [4]

India's Traditional Energy Security and Oil Dependence

India's traditional approach to energy security, focused on oil and gas supplies, is no longer sufficient. The clean energy transition is creating new challenges related to critical minerals, digital infrastructure, and cyber resilience. Although renewable energy can reduce fossil fuel use, India's energy dependence is shifting rather than disappearing. The country continues to rely heavily on imported crude oil due to limited domestic production, making it vulnerable to external shocks.

Oil import dependence creates two major risks. **First,** fluctuations in global oil prices increase India's import bill, put pressure on foreign exchange reserves, widen the current account deficit, and contribute to inflation by raising transport and production costs. **Second**, India's heavy reliance on crude oil from West Asia exposes it to geopolitical risks such as conflicts, sanctions, and shipping disruptions. These challenges highlight the need for diversified energy sources, greater domestic production, technological innovation, and a broader energy security strategy that includes both fossil fuels and emerging clean energy systems. [5]

Third, oil dependence has strategic implications. India must invest diplomatic effort in maintaining relations with multiple producing countries. It must also secure sea lanes, especially through the Indian Ocean and key chokepoints such as the Strait of Hormuz. This links energy security with maritime security, defense planning, and foreign policy.

Fourth, Oil dependence also affects India's maritime security, defense planning, foreign policy, and environmental goals by increasing emissions and air pollution. To reduce these risks, India has diversified oil suppliers, built strategic petroleum reserves, promoted domestic exploration, and encouraged biofuels, public transport, and electric vehicles. However, these measures cannot completely remove oil dependence.

India is also expanding solar and wind energy, battery storage, and electric mobility to improve energy security. While these technologies can reduce oil imports, they also create new forms of dependence on critical minerals and clean energy supply chains.[6]

The Rise of Critical Minerals in the Clean Energy Economy

Critical minerals are economically important minerals that face a high risk of supply disruption due to concentrated production, refining, geopolitical risks, and rising demand. They are essential for clean energy technologies and the global energy transition. Recognizing their strategic importance, the Government of India has identified **30 critical minerals**, marking a major policy shift toward securing resilient mineral supply chains for economic growth, technological development, and energy security.

Several minerals are particularly important:

- **Lithium** is central to lithium-ion batteries used in electric vehicles, consumer electronics, and grid-scale storage.
- **Cobalt** improves battery stability and performance, though efforts are being made to reduce its use.
- **Nickel** increases battery energy density, especially in long-range electric vehicles.
- **Graphite** is widely used in battery anodes.
- **Copper** is essential for electricity transmission, motors, wiring, and renewable energy installations.
- Rare earth elements, especially **neodymium** and **dysprosium**, are used in permanent magnets for wind turbines and electric vehicle motors.
- **Manganese, aluminum, silicon, and silver** also play important roles in batteries, solar technologies, and power systems.

The clean energy transition is rapidly increasing demand for critical minerals because renewable energy technologies require far more mineral inputs than conventional fossil fuel-based energy systems.[7]

Electric vehicles, wind turbines, and solar power systems require much more mineral content than conventional energy technologies, increasing global competition for critical minerals. The challenge is not only mining these minerals but also processing and refining them, which are concentrated in a few countries and create new strategic dependencies. As a result, critical mineral supply chains are becoming as geopolitically important as oil was in the twentieth century. For India, securing reliable, affordable, and sustainable access to these minerals is essential to achieve its clean energy and industrial goals.[8]

From Oil Dependence to Mineral Dependence: The New Strategic Shift

The shift from oil dependence to critical mineral dependence is changing the nature of energy security rather than replacing one dependency with another. Unlike oil, critical minerals are embedded in clean energy technologies such as solar panels, batteries, and wind turbines. However, expanding and maintaining these technologies requires a continuous supply of critical minerals. As India pursues ambitious renewable energy targets, its dependence on imported critical minerals is increasing, creating new strategic vulnerabilities and supply chain risks. [9]

There are several **important differences** between oil and mineral dependence-

First, critical mineral markets differ from oil markets. Unlike globally traded oil with relatively transparent pricing, critical mineral markets are smaller, less transparent, and often controlled by a few major players, making prices more volatile.

Second, critical mineral supply chains are far more complex, involving mining, refining, processing, and manufacturing before reaching final technologies. Disruptions at any stage can affect the entire chain. The geopolitical disruptions in West Asia demonstrated the risks of relying heavily on a single region, encouraging India to diversify energy sources, strengthen strategic reserves, and build more resilient supply networks. [10]

Third, the production and processing of many critical minerals are concentrated in a few countries, creating strategic risks beyond simple import dependence.

Fourth, critical mineral mining can cause environmental damage, water stress, and social problems, making responsible and sustainable sourcing essential.

Fifth, technological capabilities in refining, battery production, recycling, and advanced manufacturing provide a greater strategic advantage than relying only on imported raw minerals.

Oil dependence influences India's foreign policy, security, and environmental goals. To reduce these risks, India has diversified oil imports, built strategic reserves,

and promoted biofuels, electric vehicles, and renewable energy. While these efforts lower oil dependence, they also increase reliance on critical minerals and clean energy supply chains. [11] For India, reducing oil imports alone does not ensure energy security if clean energy technologies continue to depend on imported critical minerals and manufacturing equipment. The challenge is to avoid replacing one external dependency with another. Therefore, India's energy security strategy is expanding beyond crude oil to include resilient critical mineral supply chains and other strategic industrial inputs. [12]

India's Critical Mineral Vulnerabilities

India aims to expand renewable energy, electric mobility, grid infrastructure, and domestic manufacturing of batteries and solar technologies. However, achieving these goals requires secure access to critical minerals, while domestic production remains insufficient to meet the rapidly growing demand. Some vulnerabilities are -

Limited domestic reserves: India has resources of rare earths and graphite, but remains weak in lithium, cobalt, and nickel. Although new discoveries offer potential, commercial production is constrained by environmental approvals, high costs, and limited processing capacity.

Import and processing dependence: India relies heavily on imported minerals and foreign refining, creating strategic risks from export restrictions, supply disruptions, and price fluctuations.

Manufacturing dependence: Renewable energy and electric vehicle industries continue to depend on imported batteries, solar components, semiconductors, and advanced equipment, limiting domestic value addition.

Institutional challenges: Effective critical mineral security requires better coordination among ministries responsible for mining, energy, industry, trade, foreign affairs, and technology.

Technology and infrastructure gaps: Expanding mining, refining, recycling, and advanced manufacturing requires stronger infrastructure, skilled workforce, investment, and research capabilities to make India a competitive player in the clean energy economy. [13]

These vulnerabilities do not mean India is weak or unprepared. Rather, they indicate that the transition is entering a more complex phase. India has recognized the strategic importance of critical minerals, but recognition must be followed by deep structural action.

Geopolitics of Critical Minerals and India's External Environment-

The geopolitics of critical minerals is becoming central to international relations. Resource-rich countries are seeking greater control over extraction and

local value addition. Major powers are trying to diversify supply chains, reduce strategic dependence, and secure overseas assets. Industrial policy, trade policy, and strategic diplomacy are now deeply linked to clean energy supply chains. [14]

-For India, this external environment presents both risks and opportunities

A major challenge is that the processing and refining of critical minerals are concentrated in a few countries, giving them significant control over global clean energy supply chains. Export restrictions and geopolitical tensions can disrupt access and increase costs. India also faces strong competition in acquiring overseas mineral assets. Therefore, India needs a diversified strategy that combines overseas partnerships, domestic exploration, recycling, and international cooperation to secure critical mineral supplies.[15]

Resource-rich countries may change taxes, mining rules, or ownership policies, creating uncertainty for countries that rely on imported critical minerals. At the same time, rapidly growing demand for minerals such as copper, driven by renewable energy and electric vehicles, is expected to increase competition and supply risks by 2040.[16] India can strengthen energy security by building partnerships with mineral-rich countries through forums such as the Quad, BRICS, G20, and the Minerals Security Partnership (MSP). Diversifying mineral supply chains is essential to avoid replacing dependence on OPEC for oil with dependence on China for critical minerals. India should also expand cooperation in mining, technology, and sustainable resource development while strengthening ties with countries in Africa, Australia, Latin America, and Asia. In the clean energy era, energy security depends increasingly on diversified diplomacy and resilient global supply chains.[17]

Domestic Policy Responses: Building Mineral Security

India needs a broad and integrated policy response to reduce critical mineral vulnerability. No single measure will be enough. A successful strategy must combine domestic action, international cooperation, technological upgrading, and environmental responsibility.

1. Strengthening domestic exploration and mining

India should strengthen geological mapping, speed up critical mineral exploration, and ensure transparent mining policies while maintaining strong environmental and social safeguards. It should also expand domestic mining, processing, recycling, and overseas mineral acquisitions to reduce import dependence and improve long-term resource security. [18]

2. Developing refining and processing capacity

Mining alone is not enough. India must invest in chemical processing, refining, and battery-grade material production. This is where much of the strategic

value lies. Public-private partnerships, fiscal incentives, and technology collaborations can help create domestic processing ecosystems. Without these capabilities, India will remain dependent even if raw materials are available. [19]

3. Supporting battery and clean technology manufacturing

To avoid import dependence in downstream sectors, India must build competitive industries in batteries, electric vehicles, solar manufacturing, power electronics, magnets, and grid equipment. Industrial policy should focus on scale, quality, innovation, and integration with supply chains rather than short-term protectionism alone. [20]

4. Investing in recycling and circular economy systems

Recycling used batteries, electronics, and industrial waste can gradually reduce India's dependence on imported lithium, cobalt, nickel, copper, and rare earth elements. At the same time, India is strengthening critical mineral diplomacy and partnerships with countries such as Japan to secure reliable supplies and reduce dependence on a few global suppliers.[21]

5. Encouraging research and substitution

India should invest in research on alternative battery chemistries, material efficiency, and mineral substitution. For example, reducing cobalt intensity, improving sodium-ion technologies, or designing batteries with easier recyclability can lower future supply risk. Technological flexibility is a form of strategic security. [22]

6. Building strategic reserves and stockpiles

Just as strategic petroleum reserves protect against oil shocks, selective stockpiling of certain critical minerals may help manage supply disruptions. Such stockpiles should be carefully designed, based on demand projections, cost considerations, and market conditions.

7. Creating an integrated institutional framework

India needs a clear national strategy for critical minerals with better coordination among ministries and agencies. Energy transition, mining, and industrial policies should work together to build secure supply chains, increase domestic value addition, and strengthen technological capabilities.[23]

-Sustainability, Justice, and the Social Dimension

A reassessment of energy security must include justice and sustainability. Although clean energy reduces fossil fuel use, the extraction of critical minerals can lead to deforestation, water pollution, biodiversity loss, waste generation, and displacement of local communities. In India, where land and tribal rights are highly sensitive, poorly managed mining can create social conflict. Therefore, India's critical

mineral strategy must combine secure resource access with strong environmental governance, community consultation, benefit-sharing, and protection of local rights to ensure a sustainable and equitable energy transition.[24]

Domestic manufacturing, research, skills development, and recycling can create jobs, strengthen the economy, and reduce dependence on imported minerals. At the global level, India should promote responsible sourcing, fair mineral governance, and sustainable international partnerships. Ultimately, energy security is not only about securing resources but also about building a reliable, affordable, environmentally sustainable, and socially inclusive energy system through diversified imports, domestic exploration, recycling, and innovation.[25]

Reframing India's Energy Security for the Transition Era

India's traditional energy security framework has focused on securing fossil fuels, especially oil, but the clean energy transition is creating new vulnerabilities related to electricity, batteries, digital infrastructure, and critical minerals. A modern energy security strategy must therefore rest on four pillars. The **first** is **diversification**—India must diversify not only energy sources but also critical mineral suppliers, trade routes, technologies, and industrial partnerships to reduce supply chain disruptions and geopolitical risks.[26]

The **second** pillar is **domestic capability**. Strategic autonomy in the transition era depends on internal strength in exploration, processing, manufacturing, recycling, innovation, and skills. Imports may still be necessary, but dependence should be managed through capability building.[27]

The **third** pillar is **resilient diplomacy**. India should use foreign policy to secure long-term critical mineral partnerships and strengthen trusted global supply chains. At the same time, it must expand geological exploration, domestic processing, and strategic mineral governance to build a strong national energy security framework.[28]

The **fourth** pillar is **adaptive governance**. Energy security can no longer be treated as a static concept. As technologies evolve, demand patterns change, and geopolitical competition increases, policy must remain flexible and forward-looking.[29]

This reframing is essential because the clean energy transition is not only an environmental project. It is also an economic, technological, and geopolitical transformation. Countries that understand this early will be better positioned to protect their interests and lead in emerging industries. India is at a turning point in its energy journey. For many years, energy security mainly meant reducing

dependence on imported oil and protecting the country from price shocks and global conflicts. Today, the shift to renewable energy and clean technologies offers India a chance to reduce these risks. However, this transition also creates a new challenge. Clean energy depends on critical minerals such as lithium, cobalt, nickel, graphite, copper, and rare earth elements. Their supply is limited and concentrated in a few countries, creating new strategic risks.[30]

Instead of replacing oil dependence with mineral dependence, India must manage this transition wisely. India should secure mineral supplies, strengthen domestic industries, invest in recycling and innovation, and build international partnerships and To reduce future dependence on imported critical minerals, the Government of India established **Khanij Bidesh India Limited (KABIL)** in 2019 as a joint venture under the Ministry of Mines to identify, acquire, and develop overseas critical mineral assets.[31] The Energy security is no longer only about fuel; it is also about securing the materials, technology, and institutions needed for a sustainable and self-reliant future. And India's transition to a clean energy economy will significantly increase its dependence on critical minerals, making mineral security an integral component of national energy security. [32]

Conclusion

India is at a crucial stage in its energy transition. For decades, energy security focused on reducing dependence on imported oil and managing price volatility and geopolitical risks. While renewable energy and electrification can reduce these challenges, they also increase dependence on critical minerals such as lithium, cobalt, nickel, graphite, copper, and rare earth elements. To avoid replacing oil dependence with mineral dependence, India must broaden its energy security strategy to include secure mineral supplies, domestic manufacturing, recycling, technological innovation, and strategic international partnerships. Energy security is no longer only about fuel; it also depends on resilient supply chains, strong institutions, and sustainable resource governance. India's long-term success will depend on building a secure, self-reliant, and sustainable clean energy economy.

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