

Critical minerals: The missing link in India's green push

INDIA's clean energy transition will depend not just on how much renewable power it generates, but also on whether it can secure the minerals needed to build that future. Lithium, cobalt, nickel, graphite, copper and rare earth elements are becoming strategic assets as electric mobility, battery manufacturing and renewable energy expand. Yet, with demand for critical minerals projected to rise four to ten times by 2047, India faces a challenge that extends well beyond mining: building a resilient domestic ecosystem that can withstand global supply disruptions.

A recent Grant Thornton report estimates that electric vehicle battery demand alone could reach 110-130 GWh by 2030. Meeting this requirement, alongside India's target of 500 GW of non-fossil fuel capacity by the same year, will intensify pressure on mineral supplies. The ambition to achieve Net Zero emissions by 2070 makes the task even more urgent. Excessive dependence on imported minerals and processed materials could expose Indian industry to geopolitical tensions, volatile prices and export restrictions.

The National Critical Mineral Mission (NCMM), backed by an outlay of Rs34,300 crore, is an important step towards addressing these vulnerabilities. But policy intent must translate into capabilities across the entire value chain, from exploration and extraction to refining, separation, recycling and advanced manufacturing. Mining alone will not deliver strategic autonomy if higher-value processing remains concentrated overseas.

Financing is a crucial missing link. Critical mineral projects, particularly refining and recycling facilities, require substantial capital, involve technological risks and often take years to become commercially viable. Grant Thornton recommends a diversified financing architecture involving sovereign green bonds, fiscal incentives, foreign direct investment, venture capital, bank lending supported by guarantees and multilateral funding. India should also consider a dedicated sovereign critical minerals fund, drawing lessons from countries such as Canada, to support strategically important projects that private capital may initially find un-

attractive. Equally important is the opportunity presented by recycling. According to UN Trade and Development (UNCTAD), the global market for recycled critical minerals could expand from nearly \$40 billion in 2020 to \$200 billion by 2050. India should seize this opportunity by developing systems for collecting, recovering and reprocessing materials from used batteries, electronic waste and industrial scrap. A domestic recycling economy potentially worth \$10-15 billion annually would reduce import dependence, conserve resources and create new industrial capabilities. Recycling, however, requires clear standards, predictable regulations and investment in collection and processing infrastructure.

Domestic capacity must be complemented by strategic overseas partnerships. India cannot assume that its geological resources alone will satisfy future demand. Government-to-government agreements, long-term offtake contracts, public-private partnerships with global miners and investments in overseas mining and processing assets can diversify supply.

Trade policy, too, must be deployed strategically to secure access while encouraging domestic value addition. As Rabin Roy, founder-managing director of ScholarLab Foundation, points out, the challenge is not merely rising demand, but also who controls processing and captures economic value. Mineral-rich developing economies risk remaining exporters of raw materials while others reap the gains from processing and manufacturing.

Finally, fragmented policymaking must give way to coordinated execution. The Ministries of Mines, Finance, Environment, Commerce, External Affairs, Power and New and Renewable Energy, among others, need a common strategic framework. Environmental safeguards and community interests must remain integral to faster project development.

India's critical minerals strategy should be judged not by the tonnes it extracts, but by the value it creates, the supply risks it reduces and the industries it builds. Strategic self-reliance will require capital, technological depth and global partnerships. The race for critical minerals is ultimately a race to secure the foundations of India's clean energy and industrial future.



Up in the air, down memory lane

Recalling memorable flights, aviation pioneers and the enduring romance of flying



WHILE IAF does not have a unique official service-wide mascot, its official crest features a Himalayan Eagle with outstretched wings, which symbolizes the force's fighting spirit. The official IAF crest features the State Emblem of the Ashoka Lions at the top, a spread-winged Himalayan eagle inside a light blue ring, and the motto "Nabha Sparsham Deeptam" or Touching the Sky with Glory.

For human beings, accustomed to living on land, travelling over water, or in the air, whether for the excitement provided by exploration and discovery of new lands, entertainment, or in search of livelihoods, has always remained an exciting prospect.

Flying, which became possible barely 200 years ago, is probably the most exhilarating experience. And I have had my share of such excitement through incidents which I recall, some with pleasure and happiness, and some with a sense of dread.

Soon after my post-graduation, one of the attempts I made while looking for a career was to respond to an advertisement in the newspapers calling for applications for the post of Station Managers in Air India. Along with a couple of hundreds of other aspirants, I sat for an examination conducted at what was then Madras. After a break, the organisation announced that nine of us had been selected for an interview to be conducted the next day, of all places, at the then Bombay! And then followed my first experience of travelling in an aircraft. Halfway through the flight, an announcement was made that, on account of a thunderstorm at the Santa

Cruz Airport in Bombay, the aircraft may have to make an emergency landing in Karachi. First flight and first international travel, and that without a passport or visa, were the happy thoughts that flashed in my mind! Soon, however, the weather at Bombay improved, and we made a safe landing.

Another not so pleasant experience, in later years, was one of Usha, my wife, and I, returning from the then Calcutta, where I had gone for a training course at the Indian Institute of Management. All of a sudden, there was a spell of intense turbulence, and the aircraft began to swing, lurch and behave like a rollercoaster for several minutes. So scary was that experience that, for a couple of years after that, I dreaded the very thought of getting into an aircraft!

Not very different was the experience I had another time when, while I was escorting my mother to join our family at Delhi, the aeroplane managed to lose a wheel soon after taking off at Hyderabad and had to make a slow U-turn to return. It was the first flight experience for mother too, and despite my bravado, she sensed what was going on but managed to remain calm and composed.

Some events in the history of aviation in the world are worth recalling in this context. Firstly, the first controlled, sustained, and powered flight of a heavier-than-air aircraft in world history took place on December 17, 1903, near Kitty Hawk, North Carolina, USA, by American aviation pioneers Orville and Wilbur Wright. And Geraldine Mock, in 1964, created history when she became the first woman to fly solo around the world, in her Cessna 180 aircraft named 'Spirit of Columbus', completing the historic goal attempted by Amelia Earhart who, in 1928, had become the first female passenger to cross the Atlantic in an airplane.

Also, helicopter pilot Flight Lieutenant Gunjan Saxena, in 1999, achieved the distinction of becoming the first woman to fly in a combat zone during the Kargil War.



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coast of the country. Precisely what Usha and I had done while returning from Calcutta! Flights and incidents in aeroplanes have often been the subject matter for several gripping and interesting movies, both in Hollywood and the Hindi filmdom.

The 1956 vintage ground-

breaking Canadian movie 'Flight into Danger' became a great success. The most well-known among search movies, however, is the film 'airport', 1975 based on the bestselling novel of the same name written by well-known novelist Arthur Hailey. But the film that will probably remain in the minds of moviegoers for a long, long time is 'Those Magnificent Men in Their Flying Machines', a 1910-themed 1965 comedy epic: Reviewers frequently praise the movie for successfully recreating the look, humour, and gentle innocence of 1910 aviation culture and the Edwardian period through vibrant characterizations and physical comedy. There is this hilarious scene in that movie in which a German Sergeant and a soldier enter the race organised by the wealthy press baron Lord Rawnslay, from London to Paris, the very subject matter of the film. The pilot of the aircraft falls sick and the Sergeant, to the horror of the soldier, decides to fly the plane; and settles down in the Commander's seat in the cockpit, opens the flying manual and reads out loudly, "sit down", and sits down to begin the adventure!

(The writer was formerly Chief Secretary, Government of Andhra Pradesh)

AI and education: How students should use AI to study

AI can help students, but excessive reliance may weaken independent learning

LUKE ROWE

ARTIFICIAL intelligence (AI) means high school and uni students now have access to a resource that can potentially "do all the work for them". While this can reduce students' immediate stress in submitting assessments, it may negatively impact their long-term learning. As high school and uni students enter the end-of-year exam period, they might look for ways to incorporate AI into their study practices. I research the science of learning. My recent research, suggests students need to master foundational knowledge and skills before they use AI to help their learning.

Is using AI for study worthwhile?

The field of research offers a mixed bag of responses. One study suggests using AI chatbots, such as ChatGPT, during study may boost learning, motivation, critical and creative thinking, and reduce mental effort. Other reviews have pointed to the benefits of AI in tailoring learning to the individual, providing timely feedback and enhancing student engagement. But some researchers have questioned the credibility of these claims due to low-quality methods and lack of transparency of the previously-mentioned studies. This doesn't necessarily mean students shouldn't use AI to study at all. But they need to be aware of the risks that come with it.

What to watch out for

One of these risks is "cognitive offloading". This is when students become so reliant on AI completing their



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When you shouldn't use AI

This risk of "cognitive offloading" means you shouldn't use AI in every aspect of your revision, particularly when doing practice exams. Research shows, when doing mock exams, it's best to recreate the conditions of what the actual exam will be. On most occasions, this means closing the laptop, putting the phone away, setting a timer to the exam's duration, and seeing what information you can retrieve and write independently. If you do use AI to assist with practice exams it might give you a false sense of confidence. This is because AI can temporarily boost performance. But once you're faced with a real exam, you're likely to see performance collapse, which can reveal the true extent of your learning. A Chinese study, pub-

lished in June, looked at how high school students' use of AI impacted their overall learning. Findings showed students' AI use improved homework scores but also resulted in their monthly exam scores dropping about 20 per cent within a period of six months. So with this in mind, what are some ways you can use AI effectively to assist with study?

Using AI to revise

Before asking AI a study-related question, you should try to retrieve, explain, solve, summarise, or write concepts yourself. Once you've proven you can correctly recall content on your own, you might use AI to organise your notes and identify anything missing in them. If you'd like to extend yourself, you can use AI to generate practice exam questions that gradually become more challenging. You might prompt it to: "Generate five exam-style questions on [topic], increasing in difficulty for each question. Hide the answers until I attempt each one."

Using AI for feedback

Perhaps you have just

finished writing a practice essay, or you've answered a series of short answer questions. Now you're looking to see how you went. You can use AI to:

--offer personalised feedback

--simplify your explanations

--fact-check your work

--provide counterarguments and alternative explanations.

A prompt you might use could be:

"Here is my answer to an exam question. Don't rewrite it for me. Identify what I did well, what is inaccurate or missing, and the three changes that would most improve my answer. Check your feedback against the marking criteria I provide."

Striking a healthy balance

Even when you're not doing practice exams, it's good to put devices away and give yourself extended periods of study without any tech. An added benefit is that you will not be distracted by notifications from devices too. If you're tired of studying alone, and are needing human connection, you might consider meeting up with friends in a small group to prepare for exams. While AI may sometimes be helpful, giving and receiving feedback from other people can test and engage you in ways technology cannot. And when in doubt, a good principle to remember is: think first, use AI second (or, in some cases, not at all).

(The writer is Lecturer and Researcher at the Australian Catholic University, Australia)

Reforms reshape India's economic growth agenda

TAX, LABOUR AND EXPORT MEASURES TAKE CENTRE STAGE

VINCENT FERNANDES

INDIA's financial sector reforms have evolved from the foundational 1991 Liberalisation, Privatisation, and Globalisation (LPG) framework into modern structural and digital interventions aimed at sustaining a projected GDP growth rate of 6.8%-7.2%.

India's financial and structural reforms continue to anchor the country as one of the fastest-growing major economies, with the International Monetary Fund (IMF) projecting a 7% GDP growth rate for FY 2026-27 and FY 2027-28, supported by strong domestic demand, robust services activity, and steady financial intermediation.

In a major relief for Indian families and individual taxpayers, the Union Budget 2025-26 introduced substantial reforms in direct taxation, ensuring that annual incomes up to ₹12 lakh are exempt from income tax under the new regime, with the effective exemption rising to ₹12.75 lakh for salaried taxpayers on account of the standard deduction. This change reaffirmed the Government's commitment and left millions of middle-class households with higher disposable income, boosting consumption, savings, and investment.

The reforms expand the safety net for India's workforce, with nearly 10 million Gig and Platform workers receiving annual social security support. Women workers benefit from assured leave provisions, maternity benefits and improved workplace safety. Overall, the Labour Codes mark a decisive shift from rule-heavy regulation to outcome-based governance, creating one unified framework for over 50 crore workers across sectors. Additionally, the codes lay a strong foundation for a future-ready workforce and resilient industries aligned with India's long-term growth aspirations.

In a major boost to India's trade competitiveness, the Union Cabinet approved the Export Promotion Mission (EPM) as a flagship structural reform with an outlay of ₹25,060 crore for FY 2025-26 to FY 2030-31. Announced in the Union Budget 2025-26, EPM marks a strategic shift from fragmented export support schemes to a



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single, outcome-based and digitally driven framework, aimed at empowering MSMEs, first-time exporters, and labour-intensive sectors. The Mission integrates financial support (Niray Protsahan) including affordable trade finance and credit enhancement with non-financial enablers (Niray Disha) such as quality compliance, branding, logistics, and market access. In its October 2026 World Economic Outlook (WEO), the IMF projected India's growth at 7 per cent in both 2026 and 2027 on a fiscal-year basis, keeping the country among the world's fastest-growing major economies.

The 2026 forecast represents an upward revision of 0.6 percentage points from the July 2026 WEO Update and 0.5 percentage points from the April forecast. The projection for 2027 was raised by 0.3 percentage points from July and 0.5 percentage points from April.

India's economy expanded by 7.8 per cent in fiscal year 2025-26, according to the report, which presents fiscal-year data under the year in which the fiscal

period begins. On a calendar-year basis, the IMF projected India's growth at 7.4 per cent in 2026 and 7 per cent in 2027. The Fund said the upward revision "reflects stronger-than-expected momentum, supported by resilient domestic demand and robust services activity". "India's growth remained robust, underpinned by domestic demand and services, despite higher oil prices," the report said. The IMF noted that the medium-term global economic outlook had become increasingly uneven, with downward revisions concentrated in economies directly affected by the Middle East conflict and energy-importing emerging and developing economies, excluding India.

"India stands out with upward revisions, reflecting sustained momentum and growing evidence of stronger growth potential supported by favourable demographic dynamics, a large and expanding domestic market, and continued structural reforms," it said.

On inflation, the IMF projected India's consumer prices to rise by 5 per cent in 2026, compared with 2 per cent in 2025, before moderating to 4.4 per cent in 2027.

The country's current account deficit is expected to widen to 1.5 per cent of GDP in 2026 from 0.7 per cent in 2025, before narrowing to 1.3 per cent in 2027.

The IMF's baseline projections assume average oil prices of \$95.74 per barrel in 2026 and \$87.39 in 2027, compared with \$67.74 in 2025.

Global headline inflation is expected to increase to 4.7 per cent in 2026 before easing to 4.1 per cent in 2027.

"Global activity is projected to grow at 3.1 per cent in 2026 and 3.4 per cent in 2027," IMF Chief Economist Silvana Tenreiro wrote in a blog accompanying the report. The IMF warned that risks to the global economic outlook remain "skewed to the downside", particularly due to geopolitical tensions and uncertainty surrounding energy markets. "A prolonged stalemate or further escalation in the Middle East could keep energy and food prices elevated and volatile, revive inflationary pressures, worsen fiscal and external balances, and weigh on growth," the report said.