Building Resilient Mineral Supply Chains for Energy Security

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Executive summary

India's clean energy ambitions envision the decarbonisation of the economy alongside realising improvements in energy security, enabled by the domestic manufacturing of clean energy equipment. The need for greater indigenisation of manufacturing to ensure India's energy security is evident if one considers its import dependence for clean energy equipment. India imported 75 per cent of its installed solar photovoltaic (PV) modules over 2017-2022 (IEA 2022). Domestic lithium-ion battery manufacturing is largely limited to the assembly of battery packs, while the entire ecosystem for low-carbon hydrogen production in India, including domestic manufacturing of equipment, is still nascent. To become more self-reliant, the clean energy manufacturing sector in India will require access to a consistent supply of critical minerals, which are inputs in the manufacturing process. However, these minerals are often concentrated in geographies characterised by unfavourable commercial regimes or political instability; their production is often controlled by a few firms, often from countries that are geostrategic competitors; and future production is often tied up in supply contracts to cater to upcoming demand, restricting manufacturing companies' ability to rapidly scale up production due to the limited supply of inputs not bound by prior contracts.

The ongoing supply chain crisis caused by the war in Ukraine and the COVID-19 pandemic highlights the challenges associated with sourcing critical non-fuel mineral resources. Thus, India requires a concerted strategy to secure these minerals to further its energy security. This issue brief outlines the contours of a sourcing strategy to secure minerals for indigenising the manufacturing of battery energy storage systems. We use the case study of energy storage manufacturing to illustrate the fundamental principles underpinning the sourcing of non-fuel minerals, either for sectoral or economy-wide requirements.

Key findings and recommendations

a. Policy prerequisite

A key prerequisite before undertaking sourcing is estimating the type and quantity of minerals required for the domestic industry. This, in turn, depends on several policy choices, including deployment targets, the desired level of indigenous production to support the targets, the underlying technology mix, and the planning horizon for the sourcing strategy. This issue brief proposes setting up a multi-stakeholder group that coordinates and facilitates making these policy choices for India's storage requirements (Table ES1).

b. Key capabilities necessary to undertake strategic sourcing

This issue brief recommends that Khanij Bidesh India Limited (KABIL), which was set up with the objective of ensuring a consistent supply of critical minerals to cater to the requirements of domestic industries, undertake the overall coordination of strategic sourcing for India's domestic storage manufacturing industry. To effectively perform this role, KABIL needs to bolster its existing capabilities in research, coordination, and partnerships.

- **Research**: KABIL could jointly develop market intelligence capabilities in coordination with industry, think tanks, and academia to monitor supply-side developments. Supply-side tracking should at least include the available and committed portions of existing and upcoming production capacities, trends in mineral prices, the environmental, social, and governance (ESG) performance of suppliers, and policy and regulatory developments in resource-rich countries. This is essential for assessing the relative merits of various sourcing options.
- **Coordination**: KABIL should closely coordinate with the industry to identify contexts in which government-led interventions are necessary for securing access to raw materials and those in which sourcing should be private-sector led.
- **Partnerships**: KABIL should leverage its position as a sovereign entity and, in coordination with the Ministry of Commerce and Industry and the Ministry of External Affairs, craft government-to-government partnerships to facilitate mineral sourcing.

c. Key considerations in the implementation of sourcing strategies

To successfully secure supplies of critical minerals, KABIL must consider the following aspects while designing sourcing strategies.

- **Conditions necessitating intervention**: It is important to first determine whether private sector–led efforts are adequate or if government-led interventions are necessary. In case market tracking indicates that there is adequate supply in conducive geographies to meet India's requirements, the private sector should be encouraged to secure its own raw materials. In case an adequate mineral supply does not exist, KABIL should intervene to secure it.

Table ES1 Multi-stakeholder group for coordinating and facilitating mineral sourcing

Function	Entity
Periodic demand estimation to meet energy storage demand across sectors	Central Electricity Authority (Ministry of Power)
Deployment targets for energy storage (five-year plans)	Ministry of New and Renewable Energy
Technology tracking in domestic and international markets and their ranking as per technology and market readiness levels (TRL and MRL)	Department of Science and Technology (Ministry of Science and Technology)
Overall coordination and execution of strategic sourcing	Khanij Bidesh India Limited (Ministry of Mines)

Source: Authors' analysis

Table ES2 Trade-offs associated with the various modes of mineral procurement

Mode of procurement	Management control	Permitting risk	Exploration risk	Operational risk	Capital investment in physical assets	Investment in the equity of existing operations
Supply contract	No	No	No	No	No	No
Greenfield investment (sole management control)	Yes	Yes (highest)*	Yes	Yes	Yes (highest)**	No
Greenfield investment (joint venture)	Yes	Yes (lower)	Yes	Yes	Yes (lower)	No
Acquisition	Yes	Yes (lowest)	No	Yes	Yes (lowest)	Yes (high)
Minority stake	No	No	No	No	No	Yes (low)

Source: Authors' analysis

**Note 1: Permitting risk is higher relative to joint ventures, in which the risk is shared with and potentially reduced by the in-country expertise of the joint venture partner, and acquisitions, in which case ongoing operations have low permitting risk.*

***Note 2: Relative to capital expenditure for operations of the same capacity through the acquisition or joint venture routes.*

- **Type of intervention**: A number of sourcing options exist for mineral procurement, spanning supply contracts, greenfield investments in mines – either by a single entity or through a joint venture, and acquisitions. While each sourcing option affords differing levels of control over supply chains, each one also entails varying levels of risk (Table ES2) – the report examines these trade-offs in detail**.** The appropriate mode of procurement is contextual and depends on the desired extent of de-risking in supply chains. This issue brief recommends that KABIL follow a stepwise approach to select the appropriate intervention.
  - **i. Aggregator of supply contracts:** KABIL should first consider pre-emptively signing supply contracts to secure available production capacities before they get tied up in contracts with international companies. KABIL would, in effect, act as an aggregator of supply contracts, procuring from sellers across the world and, in turn, supplying to domestic manufacturers. Securing industry buy-in is essential before making such interventions, to determine the domestic industry's willingness to sign back-to-back sales agreements with KABIL. Such centralised procurement offers economies of scale and could potentially be secured on preferential terms.
  - **ii. Equity investments**: If the supply contract route is inadequate for securing mineral supplies, KABIL could consider making equity investments in resource-rich geographies that the private sector deems too risky. To mitigate investment risks, KABIL should jointly invest with sovereign entities from geostrategic partners or private-sector entities with in-country expertise in the jurisdictions of interest.

1. Introduction

The Ukraine crisis has shone a spotlight on the fragility of non-fuel mineral supply chains. Following hard on the heels of supply disruptions caused by the Covid-19 pandemic, heightened geopolitical tensions have further intensified concerns over the availability of key industrial metals that are geographically concentrated in a few countries, sending prices skyrocketing (Home 2022). This includes metals that underpin the energy transition such as nickel, used in the manufacture of lithium-ion batteries, and palladium, used to manufacture electrolysers. Potential disruptions to these supply chains not only undermine the pace of the energy transition, but they also pose a threat to energy security as they make it more challenging for countries to reduce their reliance on fossil fuels. This is particularly challenging for a country like India, which depends on imports for around 85 per cent of its oil requirements and 50 per cent of its gas needs (PPAC 2022).

Securing access to key minerals such as lithium, cobalt, nickel, and rare earth metals is critical for building resilient indigenous supply chains across the solar photovoltaic (PV), storage, and green hydrogen sectors and realising India's goal of energy independence by 2047 (PIB 2021b). These minerals also have wider

> **Supply chain disruptions undermine the energy transition and pose a threat to national energy security.**

applications in the chemical, medical, aerospace, and electronics industries. Thus, reliable access to such metals is important to India's endeavour to achieve greater self-reliance in manufacturing under its *Make in India* initiative.

As a first step towards the strategic sourcing of non-fuel minerals, the Government of India established Khanij Bidesh India Limited (KABIL) in 2019 with a mandate to secure mineral supplies for its domestic industries (PIB 2019). With the kernel of an institutional structure in place, the Government of India can now further bolster it and operationalise strategies to systematically assess the availability of, and secure access to, strategic minerals. Sourcing strategies could either be sectoral (catering to the mineral requirements of certain sectors) or economy-wide (procuring supplies for all the relevant sectors in aggregate). In either case, the key principles underpinning sourcing strategies would not change significantly. This issue brief identifies these key principles by outlining a sourcing strategy for securing minerals to indigenise energy storage manufacturing systems.

The issue brief first examines key policy considerations that determine the scale and types of minerals the domestic industry requires. It demonstrates how these considerations link to mineral requirements through a case study of India's storage sector. Building further on the estimation of mineral needs, the issue brief makes a case for why India needs to develop sourcing strategies for its domestic requirements. The issue brief next assesses the trade-offs associated with various mineral procurement options, before detailing the major facets of a sourcing strategy. These include the key capabilities necessary for undertaking strategic sourcing and salient points for implementation.

2. Sizing the mineral supply required for indigenous storage manufacturing

The battery manufacturing supply chain has multiple stages, including mineral extraction and purification, active electrode material and electrolyte manufacturing, electrode manufacturing, cell manufacturing, and battery pack assembly. Currently, the majority of domestic battery manufacturers focus on cell manufacturing and battery pack assembly, thereby excluding the upstream portion of the supply chain.[1]

The production-linked incentive (PLI) scheme for advanced chemistry cell (ACC) battery storage manufacturing, announced in 2021, requires manufacturers to achieve 60 per cent indigenisation within five years of commencing operation without providing explicit guidance on the specific stages of the value chain to be indigenised (PIB 2021a). While studies indicate that achieving the 60 per cent threshold for value capture is possible with only battery and cell manufacturing (NITI Aayog and Rocky Mountain Institute 2017), stakeholders should be cognisant of two additional considerations. First, the extent of value capture in the upstream stages of the storage supply chain is dependent on the prices of mineral raw materials. Value capture in the upstream stages may be higher in scenarios with elevated commodity prices. Second, the lack of control over mineral supplies leaves domestic manufacturing vulnerable to fluctuations in pricing and the availability of critical minerals (Campagnol, Pfeiffer, and Tryggestad 2022). Expectedly, many large battery manufacturers like Tesla are planning to enter the mineral acquisition and processing business to build resilience against external supply chain shocks (Ogilvy 2019; Scheyder, Matthews, and Orr 2022).

To illustrate the principles associated with strategic sourcing, this issue brief assumes a scenario of higher indigenisation, where domestic manufacturers are actively investing in electrode and electrolyte manufacturing and, thereby, looking to secure a reliable supply of necessary mineral inputs. Securing access to mineral inputs encompasses two distinct aspects – mineral extraction and mineral processing. However, while mineral processing facilities can be constructed, much like cell or battery manufacturing facilities, the availability of mineral ores can become a key bottleneck in the absence of viable alternatives. Therefore, this issue brief focuses on the bottleneck of access to mineral ores. However, a more comprehensive evaluation of the need to set up domestic mineral processing facilities is an important facet of the overall assessment of requirements for building resilient clean energy supply chains and should be considered separately.

1 Based on industry interactions.

2.1 Key policy prerequisites for strategic sourcing

A key prerequisite for charting any sourcing strategy is estimating the type and quantity of minerals required to support domestic manufacturing. This, in turn, depends on deployment targets, choice of technology, and the planning horizon.

Deployment targets

To determine the scale of domestic manufacturing required for any application, the first step is to determine deployment targets, including the desired level of indigenous production to support these targets. To estimate the scale of mineral supplies required for the desired level of indigenous production, it is important to determine which technologies to use and the timelines over which to procure these minerals.

Technology

Currently, lithium-ion-based storage is the dominant technology used across applications. However, as India is deficient in several key minerals associated with this technology, it could choose to deploy technologies in which it is less import dependent. The recovery of minerals through urban mining could also help lower the dependence on more challenging sourcing options and influence the choice of technology. However, given that lithium-ion-based technology is currently the most commercially viable, India's manufacturing and sourcing decisions through 2030 could encompass a portfolio of technologies, with lithium-ion continuing to play a dominant role.

Planning horizon

Raw material sourcing decisions should ideally secure long-term access to minerals. However, locking in supplies for long horizons entails the risk of the technology becoming obsolete. Thus, planning horizons should strike a balance between the commercial viability of technologies and long-term resource security.

> **The type and quantity of minerals needed for domestic manufacturing depend on deployment targets, choice of technology and the planning horizon.**

Since the objective of strategic sourcing is to support domestic manufacturing, the minimum planning horizon should correspond to at least one investment cycle of the useful life of battery manufacturing facilities (5–7 years) to effectively de-risk domestic manufacturing investments.

Determining the deployment targets, the technology mix, and the planning horizon for India's mineral sourcing strategies should be a periodic exercise requiring coordination between a number of actors spanning the Ministries of Power, New and Renewable Energy, and Science and Technology. Table 7 summarises the key functions involved and the actors best placed to undertake them.

2.2 Mineral demand of key battery technologies

With a 93 per cent share, lithium-ion-based batteries dominate new energy storage deployments globally (IEA 2021a). These batteries have several chemical formulations like lithium nickel manganese cobalt (NMC), lithium ferro phosphate (LFP), lithium nickel cobalt aluminium oxide (NCA), lithium manganese oxide (LMO) with graphite (LMO-G), or lithium titanate (LMO-LTO). Each chemical combination has a different energy density and mineral composition.

The Argonne National Laboratory's Battery Performance and Cost (BatPac) model is used to estimate the total mass (kg/kWh) of the different compounds used in the various components (active electrodes, electrolytes, separators, and current collectors) of lithium-ion battery cells (Argonne National Laboratory 2020). These estimates are then converted to elemental requirements using stoichiometric calculations. Table 1 shows the requirement (in tonnes) of key minerals to manufacture one gigawatt-hour (GWh) of different lithium-ion battery cells. Low energy density chemistries like LFP-graphite, LMO-graphite, and LMO-LTO have a greater mineral requirement than high energy density counterparts like NMC-graphite variants. However, the criticality of the minerals used in these chemistries varies. The next section delves deeper into these aspects.

Table 1 The mineral requirements of different lithium-ion-based batteries (tonnes/GWh)

Technology	NMC (111)-graphite	NMC (532)-graphite	NMC (622)-graphite	NMC (811)-graphite	NCA-graphite	LFP-graphite	LMO-graphite	LMO-LTO
Lithium	132	126	110	93	102	96	94	307
Manganese	336	293	170	72	0	0	1,432	2,050
Iron	0	0	0	0	0	731	0	0
Nickel	359	522	545	614	674	0	0	0
Cobalt	360	210	182	77	127	0	0	0
Phosphorus	13	12	12	11	11	427	15	43
Aluminium	186	175	163	162	171	262	241	691
Fluorine	48	44	43	42	41	77	56	157
Copper	328	311	287	284	265	466	439	0
Graphite	902	879	886	915	905	1,055	796	0
Titanium	0	0	0	0	0	0	0	1,393
Total	**2,664**	**2,572**	**2,398**	**2,270**	**2,296**	**3,114**	**3,073**	**4,641**

Source: Authors' analysis based on BatPac model (Argonne National Laboratory 2020)

3. Present landscape of mineral sourcing and availability

The previous section illustrated the scale of the sourcing challenge for the domestic manufacturing of lithium-ion storage technologies – 2,200–4,600 tonnes of minerals per GWh. However, currently, there is a huge gap between the domestic reserves[2] of major minerals used in electrochemical storage technologies and their expected demand by 2030. For example, in the case of cobalt, India does not have any proven or probable reserves (IBM 2019). Existing cobalt deposits in Odisha do not yet meet the criterion of economic viability, which means that India has to import its current cobalt requirements (IBM 2019). In the case of nickel, India's demand is also currently met via imports (CARE Ratings 2019).

The case for lithium is similar: India currently imports lithium to fulfil its needs. The discovery of 1,600 tonnes of lithium in Karnataka in 2021 marks the first-ever discovery of lithium deposits in India (PIB 2021c). Unlike lithium, cobalt, and nickel, India is well endowed with reserves of other minerals such as manganese, graphite, phosphorus, and iron (as depicted in Table 2). Prima facie, these reserves could provide a substantial portion of the raw materials required to scale up domestic storage manufacturing. However, determining whether

Table 2 India lacks key minerals necessary for deep indigenisation of lithium-ion based battery manufacturing

Mineral	Expected mineral intensity of lithium-ion batteries (tonnes/GWh)	Proven and probable reserves (kilo tonnes, kt)
Cobalt	77–360	0
Lithium	93–307	0
Nickel	359–674	0
Graphite	796–1,055	7,960*
Manganese	72–2,050	93,475
Phosphorous	11–427	45,807
Iron	731	5,494,451

**Note: The bulk of these reserves do not correspond to grades suitable for manufacturing electrodes (IBM 2020).*

Source: Authors' compilation based on data from ENVIS Centre on Environmental Problems of Mining (2018). The data refers to India's mineral endowment as of April 2015, which was the latest update available at the time of writing.

2 Economically mineable part of an indicated or measured mineral resource.

Table 3 Cobalt mineral reserves are concentrated in jurisdictions with poor commercial and governance indicators

Country	Concentration of world reserves (%)	Ease of Doing Business Index (rank out of 190)	Worldwide Governance Indicator (WGI)*						Policy Perception Index**
			WGI 1	WGI 2	WGI 3	WGI 4	WGI 5	WGI 6	
Democratic Republic of Congo	46	183	14	7	3	5	3	3	78
Australia	18	14	93	73	94	98	92	94	4
Cuba	7	NA	11	65	45	6	44	50	NA
The Philippines	3	95	41	19	56	53	32	34	NA
Russia	3	28	20	21	55	36	23	19	46
Canada	3	23	96	90	94	94	93	92	5

Source: Authors' compilation based on the United States Geological Survey (2022a) and The World Bank (2020, 2021)

**Note 1: The table captures the percentile score of each country (0–100) on the WGI indicators, with higher scores indicating better rankings: WGI 1 = voice and accountability, WGI 2 = political stability and absence of violence/terrorism, WGI 3 = government effectiveness, WGI 4 = regulatory quality, WGI 5 = rule of law, and WGI 6 = control of corruption.*

***Note 2: Based on the Annual Survey of Mining Companies, 2021, which rated 84 national and sub-national jurisdictions. Each mining state in Australia and Canada is assigned a separate Policy Perception Index rank. The rank mentioned in the table for these two countries corresponds to the top-rated state.*

these reserves are adequate to meet India's demand for domestic storage manufacturing by 2030 and beyond requires a deeper analysis of the competing demands for these minerals from other sectors of the economy.

Given the status of India's current reserves of key minerals such as cobalt, lithium, and nickel, securing access to a reliable supply of these raw materials is a prerequisite for setting up domestic manufacturing of energy storage. It is hence important to understand the current status of global mineral supply chains in order to identify and mitigate risks to India's domestic storage manufacturing ambitions.

- **Concentration of reserves in unfavourable jurisdictions**: Reserves of key minerals are concentrated in specific geographies, many of which have unfavourable commercial regimes (in terms of the ease of doing business economy-wide or in the mining sector) or political instability. These factors can heighten the risks of supply disruptions and reduce the attractiveness of new investments. For example, in the case of cobalt, the Democratic Republic of Congo (DRC) ranks poorly (183/190) on the World Bank's Ease of Doing Business Index (The World Bank 2021) and ranks in the bottom 15th percentile of countries for each facet of the World Bank's Worldwide Governance Indicators (The World Bank 2021). This is due to poor infrastructure, high incidence of corruption, resource nationalism, a history of civil wars in the 1990s and 2000s, as well as historical conflict and ongoing tensions with neighbouring countries (Slack, Kimball, and Shedd 2017). It also ranks poorly (78/84) on sectoral regulations, as per the Fraser Institute's Policy Perception Index. Published as a part of the Fraser Institute's *Annual Survey of Mining Companies 2021*, the Policy Perception Index captures industry perceptions of the attractiveness of a jurisdiction's mining policies. In the case of lithium, resource-rich countries such as Chile and Argentina have mediocre ratings in terms of governance and ease of doing business indicators. Chile is also in the process of re-writing its constitution and may further regulate its mining industry (Cambero and Pulice 2022). These countries have middling rankings in terms of the attractiveness of their mining policies. The dependence of supply chains on such jurisdictions heightens the risk of supply disruptions. Tables 3 and 4 show the concentration of minerals in key jurisdictions.

- **Concentration in production**: In addition to the geographical concentration of mineral reserves, the actual mining of ores is often concentrated in the hands of a few, large corporations. For example, in the case of lithium, only five companies controlled three-fifths of the global lithium production in 2019 – Albemarle (24 per cent), SQM (12 per cent), Tianqi Lithium (11 per cent), Mineral Resources (8 per cent), and Galaxy Resources (6 per cent) (IEA 2021b). Such concentration in production creates two distinct challenges for sourcing. First, disruptions in the operations of a few companies can adversely impact global production and prices. Second, the sourcing of minerals may be further complicated if their production is vulnerable to being influenced

Table 4 Lithium mineral reserves are concentrated in jurisdictions with mediocre commercial and governance indicators

Country	Concentration of world reserves (%)	Ease of Doing Business Index (rank out of 190)	Worldwide Governance Indicator (WGI)*						Policy Perception Index (rank out of 84)**
			WGI 1	WGI 2	WGI 3	WGI 4	WGI 5	WGI 6	
Chile	42	59	81	49	81	82	84	84	38
Australia	26	14	93	73	94	98	92	94	4
Argentina	10	126	66	49	43	32	35	50	20
China	7	31	5	38	73	50	53	53	73
USA	3	6	73	46	87	88	88	83	6

Source: Authors' compilation based on United States Geological Survey (2022a) and The World Bank (2020, 2021)

**Note 1: The table captures the percentile score of each country (0–100) on the WGI indicators, with higher scores indicating better rankings: WGI 1 = voice and accountability, WGI 2 = political stability and absence of violence/terrorism, WGI 3 = government effectiveness, WGI 4 = regulatory quality, WGI 5 = rule of law, and WGI 6 = control of corruption.*

***Note 2: Based on the Annual Survey of Mining Companies 2021, which rated 84 national and sub-national jurisdictions. Each mining state in Argentina, Australia, and the USA is assigned a separate Policy Perception Index rank. The rank mentioned in the table for these three countries corresponds to the top-rated state.*

by India's geostrategic competitors. For example, if one considers the cobalt supply chain, one company (China Molybdenum), accounting for ~10 per cent of global production, is directly owned by China (IEA 2021b). Further, Chinese middlemen control artisanal cobalt mining supply chains in the DRC, while Chinese companies have partnered with Gecamines the DRC's state-owned miner, on mining projects (Sanderson 2020; Reuters 2022). In addition, with around two-thirds of the global cobalt processing capacity based in China (IEA 2021b), the country accounts for a disproportionately large share of the demand for cobalt ore and, thereby, can potentially influence production decisions. Tensions with such geostrategic competitors could thus increase the risk of supply chain disruptions.

- **Future production capacity commitments in existing supply contracts**: An important facet of mineral demand–supply dynamics is that both existing and future production capacities are often tied to supply contracts. For example, consider Glencore, the world's largest cobalt miner. It signed new supply contracts in the second half of 2019 and the first quarter of 2020 (each 5–6 years in duration) that equated to around 70 per cent of its projected average annual cobalt production over 2020-2022 (Glencore 2020) (Table 5). The figure for capacity tied up in supply contracts could be even higher, as only committed capacity for select supply contracts was disclosed. According to a study by the International Energy Agency (IEA), by 2040, the demand for minerals for clean energy technologies will be four times the demand in 2020 if countries make concerted efforts to achieve the Paris Climate Agreement goals (IEA 2021b). If existing and future production capacity of mining companies continue to be tied up in supply contracts to cater to upcoming demand, it could create challenges in sourcing these minerals in the absence of a sourcing strategy.

Given the complexities associated with the sourcing of minerals, developing a concerted, strategic approach is necessary to mitigate risks and secure a resilient supply of mineral raw materials for domestic energy storage manufacturing.

Table 5 Glencore's major cobalt supply contracts signed in 2019 and early 2020

Customer	Location of headquarters	Contract
Umicore	Belgium	Quantity undisclosed
GEM	China	61,200 tonnes between 2020 and 2024
SK Innovation	South Korea	30,000 tonnes between 2020 and 2025
Samsung	South Korea	21,000 tonnes between 2020 and 2024

Source: Authors' compilation based on Glencore (2020)

3.1 Understanding the trade-offs associated with various sourcing options

Sourcing minerals from international jurisdictions involves multiple possible modes of procurement (Table 6). These options offer varying degrees of control over supply chains but are also characterised by varying levels of risk. Understanding these trade-offs is essential to developing a strategy for sourcing minerals.

- **Supply contracts**: A supply contract is a bilateral agreement for the delivery of a specified quantity of minerals over a number of years. Supply contracts do not give the investor any authority over the production decisions of the counterparty (mining or mineral processing firm) and, thus, offer the least amount of control over supply chains. At the same time, the contracts do not require the investor to take on the risks of getting the requisite regulatory approvals and permits (permitting risk), prospecting for minerals (exploration risk), or the risk of disruptions to operations from external and internal factors (operational risk), or make investments in the counterparty. Thus, this option entails the lowest cost and risk but also offers stakeholders the least control over supply chains.
- **Greenfield investments (sole management control)**: Greenfield investments involve building a mining facility from the ground up in a foreign country. Such investments offer the investor control over production decisions. However, they also require investors to make considerable capital investments and take on permitting, exploration and operational risks. Such decisions are much more complex to plan than simply signing supply contracts.
- **Greenfield investments (joint venture)**: Instead of sole management control, joint ventures offer control that is shared with other investors, typically local companies. The networks and in-country expertise of the local partner can help reduce the permitting and operational risk of the overall venture. The local partner could also share the burden of capital investments. Therefore, joint ventures represent a relatively low-cost way for investors to achieve control over production decisions.
- **Acquisition**: Making an acquisition involves purchasing existing production facilities instead of building them from scratch. It thus offers a faster route to gain a foothold in a supply chain compared to greenfield investments. While the scale or scope of operations may be expanded or modified by the acquirer, investing in ongoing operations typically entails lower permitting and exploration risks. Since the acquirer takes control of existing mines, the acquisition route is typically associated with a lower capital investment in new physical assets. However, making an acquisition could mean that buyers have to pay a premium to take control of the equity stake of the seller, which seeks to make a profit on its own investment.
- **Minority stake**: A minority equity stake in the producer does not offer the investor any management control. However, large minority investors may have some influence on production decisions. From a strategic perspective, acquiring a minority stake may be viewed as an intermediate step towards securing management control.

Table 6 Trade-offs associated with the various modes of mineral procurement

Mode of procurement	Management control	Permitting risk	Exploration risk	Operational risk	Capital investment in physical assets	Investment in the equity of existing operations
Supply contract	No	No	No	No	No	No
Greenfield investment (sole management control)	Yes	Yes (highest)*	Yes	Yes	Yes (highest)**	No
Greenfield investment (joint venture)	Yes	Yes (lower)	Yes	Yes	Yes (lower)	No
Acquisition	Yes	Yes (lowest)	No	Yes	Yes (lowest)	Yes (high)
Minority stake	No	No	No	No	No	Yes (low)

Source: Authors' analysis

**Note 1: Permitting risk is higher relative to joint ventures, in which the risk is shared with and potentially reduced by the in-country expertise of the joint venture partner, and acquisitions, in which case ongoing operations have low permitting risk.*

***Note 2: Relative to capital expenditure for operations of the same capacity through the acquisition or joint venture routes.*

4. Securing key mineral inputs: a mineral sourcing strategy for domestic storage manufacturing

Given the absence or limited availability of key lithium-ion-battery raw materials in India and the evolving landscape of global supply chains, India should strategically develop a plan to secure adequate access to these raw materials to support the indigenisation battery manufacturing. A competent government entity could be tasked with developing such a sourcing strategy.

KABIL – a joint venture company set up with the participation of three public sector enterprises, National Aluminium Company Ltd (NALCO), Hindustan Copper Ltd (HCL), and Mineral Exploration Company Ltd (MECL) – is best placed to take on such a role. KABIL has already been tasked with carrying out the identification, acquisition, exploration, development, mining, and processing of strategic minerals overseas for commercial use and with meeting the country's requirement of minerals identified as critical and strategic (PIB 2019). This section elaborates on the capabilities necessary to undertake strategic sourcing and elaborates on the salient aspects of implementation.

4.1 Key capabilities

To effectively perform this role, KABIL could consider bolstering its existing capabilities and incorporating the following facets into its operations.

- **Research**: Tracking and monitoring supply-side developments, such as the available and committed portions of existing and upcoming production capacities, mineral prices, as well as economy-wide and sector-specific policy and regulatory developments in resource-rich countries can provide relevant data that informs sourcing strategies. Another important facet of supply-side tracking is to evaluate the environmental, social, and governance (ESG) performance of suppliers, to ensure the ethical sourcing of mineral supply. KABIL should either enhance its in-house market intelligence capabilities or jointly develop them in coordination with the industry, think tanks, and academia. Other countries are either contemplating or taking steps to bolster their capabilities in this regard; e.g., the UK launched its data centre for critical minerals in July 2022 to gather and analyse data on the supply of critical minerals (Onstad 2022). The centre is run by the British Geological Service.

> **Coordination with the industry can help KABIL identify specific contexts in which government-led interventions are necessary to secure access to minerals.**

- **Coordination**: Since the purpose of strategic sourcing is to de-risk domestic investments in battery manufacturing (and possibly extend to other domestic investments in clean energy equipment manufacturing, such as electrolysers and solar PV modules), there could be considerable value in coordinating with the domestic industry to devise sourcing strategies. This would help with clearly identifying specific contexts in which government-led interventions are necessary to secure access to raw materials.
- **Partnerships**: As a sovereign-controlled entity, KABIL is in a position to leverage government-to-government partnerships to facilitate the sourcing of minerals. For this purpose, coordination with the Ministry of Commerce and Industry (responsible for trade policy and concluding trade agreements) and the Ministry of External Affairs (responsible for matters pertaining to foreign policy) is necessary. These government entities could consider coordinating with one another to craft direct agreements with the governments of resource-rich countries and explore the possibility of joint mineral sourcing through geostrategic partnerships such as the Quadrilateral Security Dialogue (Quad).[3] Jointly working towards establishing resilient clean energy supply chains is a priority for these countries. (The White House 2021).

4.2 Implementing the sourcing strategy

This section outlines key considerations for the implementation of sourcing strategies.

- **Conditions necessitating intervention**: The overall objective of strategic sourcing is to reduce the risks associated with investing in domestic battery manufacturing. It aims to secure minerals whose supply chains are characterised by uncertainty. Inputs from the domestic industry should inform decision-making regarding government-led interventions. In order to develop a considered view on mineral availability, KABIL could consider performing the following steps.

3 'The Quad' is a strategic partnership involving four nations – Australia, India, Japan, and the USA.

i. **Map out existing and planned production by mining companies** (including plans by Indian private sector companies), taking into consideration a desired cut-off mineral grade (determined in consultation with the industry). Any sources of supply considered untenable due to geopolitical sensitivities (e.g., companies controlled by Chinese investors) or other considerations (e.g., poor ESG performance of the supplier) could be filtered out if deemed necessary. As an outcome of this exercise, KABIL can identify supply options that conform to the desired range of production costs and exclude geopolitically sensitive or otherwise untenable options.

ii. **Assess the extent of the identified production capacity** committed under existing supply contracts with customers. Determining the scale of available production capacities (that is, capacity not committed in supply contracts) provides a perspective on the mineral supply during the planning horizon. If there is adequate visibility on supply in conducive geographies per India's requirements (determined in consultation with the industry), the private sector should be encouraged to secure its own raw materials. However, in case the supply mapping exercise does not indicate adequate supply to cater to India's requirements, or if requested to do so by the industry, government-led market interventions will become necessary.

- **Type of intervention**: While several sourcing options exist for government-led interventions, the risks associated with each option and the extent of supply chain de-risking necessary would ultimately inform the choice of sourcing options. The different levels of risks associated with each sourcing option (Table 7) translate into a hierarchy of preferences.

While several options exist for government-led interventions, the risks associated with each and the extent of supply chain de-risking necessary would inform the choice of sourcing options.

i. **Aggregator of supply contracts**: The simplest sourcing option is to pre-emptively sign supply contracts to secure the available production capacity before it is tied up in contracts with international companies. Here, KABIL can procure from sellers from across the world and sign back-to-back sales agreements with domestic private-sector manufacturers. Industry buy-in is necessary before such interventions to predetermine the extent of interest in signing sales agreements with KABIL. Such centralised procurement could benefit from economies of scale and potentially be secured on preferential terms.

ii. **Equity investments**: If aggregating available supply through supply contracts is not sufficient to meet domestic requirements, KABIL could consider making equity investments in resource-rich geographies that the private sector deems too risky. To mitigate investment risks, KABIL should jointly invest with sovereign entities from geostrategic partners or private-sector entities with in-country expertise in the geographies of interest.

Table 7 summarises the key functions and corresponding entities involved in the strategic sourcing of minerals.

Table 7 Composition and responsibilities of the proposed multi-stakeholder group for strategic sourcing

Function	Entity
Periodic demand estimation to meet energy storage demand across sectors	Central Electricity Authority (Ministry of Power)
Deployment targets for energy storage (five-year plans)	Ministry of New and Renewable Energy
Technology tracking in domestic and international markets and ranking as per technology and market readiness levels (TRL and MRL)	Department of Science and Technology (Ministry of Science and Technology)
Overall coordination and execution of strategic sourcing	KABIL (Ministry of Mines)

Source: Authors' analysis

5. Conclusion

Given that the stakes at play include energy security and industrial self-reliance, securing access to a steady source of non-fuel mineral inputs is a strategic imperative for India. As this issue brief illustrates, it is also a complex process involving the development of institutional capabilities, careful assessment of key policy choices, and close coordination between several actors. The multifaceted issues involved point to the need for urgent policy action amid an increasingly uncertain global geopolitical landscape. While the considerations presented in this issue brief are by no means the final word, they may serve as starting points to develop strategies for sourcing minerals for either sectoral or economy-wide requirements.

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