Assessing Risk of Upstream Mineral Supply Disruptions for Battery Energy Storage Systems

BUSINESS PROBLEM

Lithium-ion battery energy storage systems (BESS) are scaling rapidly as a core component of renewable energy deployment. This growth increases reliance on globally concentrated supplies of lithium, copper, aluminum, and graphite. Increasingly frequent export restrictions and trade disruptions create uncertainty in battery pricing. For developers operating at gigawatt deployment scale, even small cost increases materially affect project economics. Existing frameworks do not quantify this risk at the system level.

DATA SOURCES

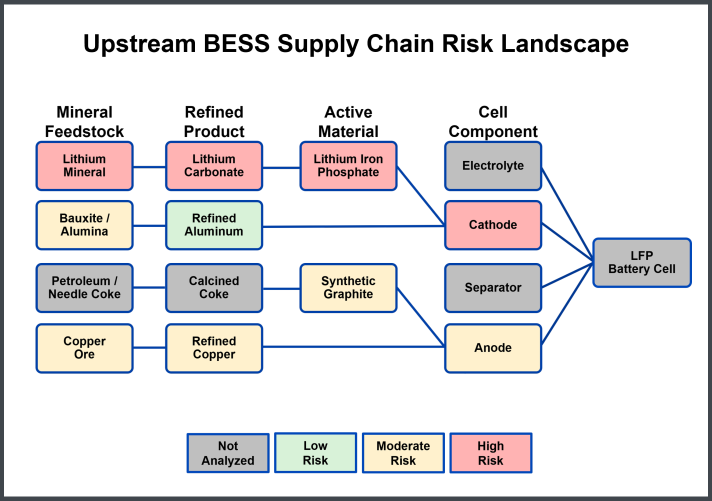
1. UN COMTRADE - global mineral trade flows and export shares
2. US Geological Survey - disruption likelihood estimates
3. Literature - mineral price elasticities of supply and demand
4. Internal company inputs - BESS cost structure and material cost shares

DATA TYPES AND FORMAT

Numeric, Relational Data, Static, Structured

APPROACH

This project developed a deterministic model to estimate how mineral supply disruptions may affect BESS costs. Global export concentration, disruption likelihood, and price elasticities were used to calculate post-disruption mineral prices. These impacts were then propagated through a cost structure from raw materials to cells, battery packs, and full systems. A likelihood-weighted index was created to compare and prioritize disruption risks.



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IMPACT

The model quantifies how upstream mineral supply disruptions translate into BESS system cost increases, enabling direct evaluation of supply chain risk in financial terms. Results show that lithium disruptions create the largest exposure. Complete export restrictions from major producers can increase system costs by more than 20% under baseline assumptions. In contrast, copper and aluminum disruptions produce large commodity price increases but smaller system impacts due to their lower cost share within battery cells.

The likelihood-weighted disruption index distinguishes between high-impact, low-likelihood events and structurally persistent risks with meaningful expected exposure. This allows developers to prioritize mitigation strategies based on likelihood-adjusted impact rather than worst-case outcomes alone.

For leading BESS developers, the model provides a structured framework to evaluate procurement risk, inform supplier diversification strategies, and support scenario-based planning. It enables comparison of country–mineral risk nodes and highlights where mitigation efforts can reduce exposure most effectively. At multi-gigawatt deployment scale, even low single-digit percentage cost increases translate into significant capital exposure across the project portfolio, making proactive risk assessment critical for long-term planning.

DRIVERS

Rapid growth in BESS deployment and increasing reliance on concentrated mineral supply chains create exposure to geopolitical disruptions. Developers need a way to translate these risks into financial impact.

BARRIERS

Trade data lacks granularity and disruption likelihoods are uncertain. The model relies on short-run assumptions and simplified market behavior. Results must be updated as market conditions evolve.

ENABLERS

Public availability of global trade datasets, published mineral price elasticity estimates, and internally developed cost structures enabled model development. Industry context and internal process exposure ensured alignment with real-world procurement processes and decision-making needs.

ACTIONS

Global trade data were processed to calculate export concentration by country and mineral.
Elasticity-based price response was applied to simulate supply disruptions. These impacts were propagated through the BESS cost structure and a likelihood-weighted risk index was calculated.
An interactive modeling tool incorporating user-defined parameters was developed to simulate various disruption scenarios and allow for modelling of risk.

INNOVATION

This project connects upstream export restrictions directly to BESS system-level cost impacts using a structured economic modeling approach. It combines elasticity-based price response with tiered cost propagation across the supply chain. The likelihood-weighted disruption index integrates probability and impact into a single metric, enabling clear prioritization of supply chain risks.

IMPROVEMENT

Future work should include dynamic market responses such as inventory drawdown, substitution across battery chemistries, and production capacity expansion over time. The model can be extended to multi-country disruptions and updated cost structures. Integration with project-level financial models and supplier-specific data would improve decision-making.

BEST PRACTICES

The model should be used to compare relative risk, not predict exact outcomes. Inputs should be updated regularly as trade patterns and policies change. Results should be interpreted in the context of key assumptions such as disruption severity and cost pass-through, in addition to current supplier and contract data.

OTHER APPLICATIONS

This approach can be applied to other supply chains with concentrated upstream inputs, including electric vehicle batteries, critical minerals, and energy infrastructure. It can also support policy analysis and strategic sourcing decisions in resource-constrained industries.