

**The Dual Nature of Progress: Environmental Supply Chain Ethics in Grid Scale
Battery Energy Storage Systems**

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Introduction

One technology can stabilize the grid, make renewable energies more reliable, and reduce the carbon footprint of the grid, all while potentially destroying ecosystems, enslaving entire regions, and possibly pushing the world into the next phase of global warming. This technology, like chemotherapy, has necessary benefits that must be exploited to push mankind into the next phase of existence while simultaneously producing symptoms that, if left untreated, could very well kill the patient itself. The technology is grid-scale battery energy storage systems, or for our purposes, we will simply refer to them as BESS. “BESS can provide capacity, energy, and ancillary services, enabling utilities to optimize grid operations while integrating variable renewable resources” (Bowen et al., 2019, p. 23). BESS engages in energy arbitrage by strategically purchasing electricity when demand and prices are low, then selling it back to the grid during peak demand periods when electricity prices are elevated. This operational strategy enables BESS operators to exploit market price volatility and generate revenue through the strategic storage and dispatch of electrical energy (Akinsooto et al., 2024, p. 27). In 2024, the capacity of the domestic BESS systems grew by 66 percent, and the capacity as of January 2025 was 26 gigawatts, with an expected 75 percent growth rate for 2025. This impressive exponential growth creates a gaping vacuum of demand for raw resources to build this infrastructure. This market brings forth ethical considerations that must be taken into account.

Therefore, grid-scale battery energy storage systems (BESS) present a critical paradox for sustainable energy transition: while they are essential for stabilizing renewable energy grids and

reducing carbon emissions, their current lithium-ion technology perpetuates severe human rights violations and environmental destruction through exploitative supply chains, necessitating an immediate shift to sodium-ion alternatives to achieve truly ethical energy storage.

Historical Context

The need for energy storage became clear and urgent during the 1973 oil crisis, which shaped government policies, investment, and innovation leading to modern energy storage (Cgep, 2025). The oil shortage nearly left America in the dark. It is well known that the grid is unstable, with blackouts and brownouts common across the country due to undercapacity or other issues. In Jacobsen's (2010) essay on The Al Gore Effect, a surge in renewables is linked to the early 2000s climate change efforts. It has been observed that "BESS can store excess energy generated during periods of high RES output and release it when generation is low, effectively smoothing out the fluctuations and enhancing grid reliability" (Akinsooto, Ogundipe, & Ikemba, 2024, p. 23).

So, naturally, in response to the boom in 2012 as part of the American Recovery and Reinvestment Act, a project called The Pacific Northwest Smart Grid Demonstration (PNWSGD) was one of 16 regional projects. The author continues to state that "This region-wide connection" was "one of the major successes of the project" (Hammerstrom & Yao, 2015). During this period, the technology was expensive and not very practical to use.

However, this market opportunity created a gap that was eventually filled by Tesla, which on April 30, 2015, announced it would sell standalone battery storage products to consumers and utilities (Truong et al., 2016). It was then that Tesla stepped in to assist during the

2016 South Australian blackout and helped stabilize the grid with the Hornsdale project. The success of this initiative directly contributed to the global growth of BESS deployments.

With exponential growth (Brookhaven National Lab, 2020), the story continued into the California Wildfire Era (2018-2020), when public safety power shutoffs left millions without power during fire season. This situation led the Federal Energy Regulatory Commission (FERC) to issue order 841 in 2018, which required regional wholesale electricity markets to permit energy storage resources to participate, essentially paving the way for energy arbitrage. Followed by additional legislation, such as the IRA or the Inflation Reduction Act (Inflation Reduction Act of 2022, 2022), along with the Department of Energy's Storage Grand Challenge roadmap, which promotes their "innovate here, manufacture here, deploy everywhere" strategy (U.S. Department of Energy, 2020, p. 30-35). This cause-and-effect cycle, like a chain of events triggered by some geo/macro disaster or political incident, leading to legislation that subsidizes and incentivizes the industry, repeats many times. The development of these events has built the current multibillion-dollar industry that will continue, with or without government incentives. As the energy storage association is quoted in the grand challenge (2020), "ESA estimates that the deployment of 100 GW of energy storage by 2030 (ESA 100x30 vision) would create at least 200,000 jobs, without accounting for a surge in U.S. technology innovation or expansion of domestic manufacturing."

The Current Situation

Before Tesla, the materials and technology for batteries and the equipment needed to make it suitable for the grid were costly. When Tesla entered the scene and began developing super packs and electric vehicles, it reduced the cost of raw materials, paving the way for

exponential growth in the BESS industry. During the adoption phase of new technology, demand surges, creating supply chain bottlenecks and increasing the demand for critical minerals, which leads to an ethical sourcing crisis. Consequently, the next developments could trigger an economic disaster.

The Democratic Republic of the Congo dominates global cobalt production, providing nearly two-thirds of the world's cobalt that is vital for lithium-ion battery manufacturing (Llamas-Orozco et al., 2023). Research has documented significant human rights violations and safety hazards in Congolese cobalt extraction, including the exploitation of child workers, along with environmental contamination affecting local communities (Owen et al., 2023). Tens of thousands of children, some as young as six years old, are estimated to work in cobalt mining in the DRC, representing a substantial part of the mining workforce (Major International Battery Supply Chain Events, 2024). As of December 2023, 5,346 children were registered and known to be working in the mines because they are being assessed for services (Findings on the Worst Forms of Child Labor - Democratic Republic of the Congo, n.d.). Indigenous community displacement occurs at mining sites worldwide, with health impacts from cobalt and nickel sulfate production. Furthermore 70% of mining is occurring in indigenous/low-income areas around the world (Putsche et al., 2023, p. 2).

Reports indicate widespread, state-sponsored forced labor targeting Uyghurs and other ethnic minorities in China's Xinjiang Uyghur Autonomous Region (XUAR). This region is a major source of critical minerals in the supply chain. In response to the forced labor occurring there, the USA enacted the Uyghur Forced Labor Prevention Act, which restricts imports from regions involved in forced labor (Putsche et al., 2023, p. 2). Notably, this legislation does not

only ban the purchase of raw minerals from the region but also restricts the sale of any products made from minerals sourced in Xinjiang, China (United States of America, 2021).

South America is being heavily exploited for lithium, and the growth of its lithium mining industry has sparked widespread protests. Police and indigenous people even clashed violently in 2024 at an anti-mining protest. Lithium mining requires large amounts of water, and these mines are often located in areas where water is scarce. “Indigenous communities refuse to be part of an energy transition that generates territorial dispossession, pollution and loss of water sources,” said Jimena Cruz Mamani, a representative of the Council of Atacameño Peoples in Chile, in a press release. These problems cross borders between Argentina, Bolivia, and Chile. A summit was held in Jujuy Province, Argentina, it was attended by more than 200 people from indigenous communities in what is called the lithium triangle.

In 2023, an agreement was reached between the state-owned copper company Codelco and the private firm SQM to expand lithium extraction activities in the flats. On January 13, 2023, a protest blocking access to the Atacama erupted, demanding that the president of Chile come and give the indigenous people a seat at the negotiating table. (Business & Human Rights Resource Centre, 2024)

Bolivia is not only experiencing issues related to its territorial claim in the Atacama Desert. The country also has one of the world’s largest lithium deposits in Salar de Uyuni. There is a political divide over the contract with foreign Russian and Chinese companies Uranium One and CATL. Disruptions and protests in parliament reflect disagreements between parties. One side argues that the current agreements undervalue lithium and do little to benefit the local people who will be affected, while the other simply wants to start development. This country seems headed toward a serious internal conflict directly influenced by foreign corporations

lobbying the country (CE Noticias Financieras, 2025, February 14) and (CE Noticias Financieras, 2025, July 4).

The scenarios continue to unfold globally, where less developed economies are exploited for the benefit of corporations and more developed countries. Bolivian communities face water shortages due to lithium extraction and experience parliamentary violence over foreign contracts (CE Noticias Financieras, 2025, February 14) and (CE Noticias Financieras, 2025, July 4). Chilean Atacama peoples protest agreements that sideline indigenous water rights (Business & Human Rights Resource Centre, 2024). Congolese children are affected by high-profile lawsuits against tech giants over cobalt mining child labor (ABC News, 2024). Geographic inequality persists, with benefits in North America and costs in South American extraction sites (Grossman et al., 2023, p. 3).

Recommendation

The lithium supply chain is riddled with ethical considerations that make sourcing complicated and expensive. While Western BESS leaders invest billions securing lithium supply chains, Chinese competitors have quietly achieved major breakthroughs in sodium-ion technology. In June 2024, HiNa Battery deployed the world's largest operational sodium-ion storage system 50MW/100MWh in collaboration with China's state-owned Datang Group, marking a new stage in commercial sodium-ion battery energy storage operations (Batteries International, 2024). Meanwhile, CATL, the world's largest battery manufacturer, announced its second-generation sodium-ion batteries will hit the market in 2025, with mass production expected by 2027 using abundant, ethically sourced materials that eliminate child labor and environmental destruction (CleanTechnica, 2024).

This impressive progress in sodium-ion deployment creates a welcome opportunity for American companies to fund and lead the domestic transition. This exposes a critical strategic blind spot. Corporate leaders recognize the moral hazards in lithium-ion supply chains but focus on recycling solutions that won't materialize until 2030, when "circular economy strategies have also lagged battery deployment" (Putsche et al., 2023). Rather than waiting for future solutions, American BESS companies must invest in sodium-ion research and development to establish domestic leadership in this emerging technology before Chinese competitors capture the entire market.

Corporate policies promoting systematic sodium-ion research investment and technology endorsement create greater aggregate welfare across stakeholder groups over time. These benefits include supply chain security for shareholders, ethical sourcing for affected communities, competitive differentiation for market positioning, and technological leadership for long-term value creation, as "research is focused on identifying materials and cell chemistries that can enable sodium-based systems to have comparable energy density and life cycle performance to today's lithium-ion while eliminating the cost and supply chain constraints of lithium" (U.S. Department of Energy, 2020). Industry leading companies must fund this transition immediately to avoid being disrupted by foreign competitors who have already begun commercialization. The strategic question is not whether the sodium-ion transition will occur, but whether American companies will lead through strategic investment or surrender this critical technology to Chinese dominance.

References

- Akinsooto, O., Ogundipe, O. B., & Ikemba, S. (2024). Regulatory policies for enhancing grid stability through the integration of renewable energy and battery energy storage systems (BESS). *Int. J. Frontline Res. Rev*, 2, 022-044. <https://doi.org/10.56355/ijfr.2024.2.2.0023>
- Batteries International. (2024, July 12). World's largest sodium-ion BESS starts operation. *Batteries International*. <https://www.batteriesinternational.com/2024/07/12/worlds-largest-sodium-ion-bess-starts-operation/>
- Business & Human Rights Resource Centre. (2024, January). Chile: Indigenous groups protest against lithium agreement. *Business & Human Rights Resource Centre*. <https://www.business-humanrights.org/en/latest-news/chile-indigenous-groups-protest-against-lithium-agreement-signed-between-sqm-and-codelco-alleging-they-were-sidelined/>
- Bowen, T., Chernyakhovskiy, I., & Denholm, P. (2019). *Grid scale battery storage: Frequently asked questions* (No. NREL/TP 74426). National Renewable Energy Lab. <https://www.nrel.gov/docs/fy19osti/74426.pdf>
- CE Noticias Financieras. (2025, July 4). Bolivian Congress sparks row over lithium deals with China and Russia. Retrieved from Ex Libris: <https://go.exlibris.link/gqsJYShV>
- CE Noticias Financieras. (2025, February 14). Bolivian deputies suspended processing of lithium exploitation contracts with Russia and China. ProQuest. Retrieved from <https://go.exlibris.link/HDPMhsy2>
- CleanTechnica. (2024, November 19). CATL will put its second-generation sodium-ion batteries into production in 2025. *CleanTechnica*. <https://cleantechnica.com/2024/11/18/catl-will-put-its-second-generation-sodium-ion-batteries-into-production-in-2025/>

Findings on the worst forms of child labor - Democratic Republic of the Congo. (n.d.). DOL.

<https://www.dol.gov/agencies/ilab/resources/reports/child-labor/congo-democratic-republic-drc>

Grossman, E., Steinberg, P., Aguirre, K., & Sonter, L. (2023). Environmental justice across the lithium supply chain: A role for science diplomacy in the Americas. *Journal of Science Policy & Governance*, 22(2).

https://www.sciencepolicyjournal.org/uploads/5/4/3/4/5434385/grossman_etal_jspg_22_2_1_.pdf

Hammerstrom, D., & Yao, M. (2015). *Pacific Northwest Smart Grid Demonstration Project Technology Performance Report Volume 1: Technology Performance*. <https://go.exlibris.link/gPkdDrt4>

Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818 (2022).

<https://www.congress.gov/bill/117th-congress/house-bill/5376>

Jacobsen, G. D. (2010). *Three empirical essays on consumer behavior related to climate change and energy* [Doctoral dissertation, University of California, Santa Barbara]. ProQuest Dissertations & Theses Global. <https://www.proquest.com/docview/3428947>

Llamas Orozco, J. A., Meng, F., Walker, G. S., Abdul Manan, A. F. N., MacLean, H. L., Posen, I. D., & McKechnie, J. (2023). Estimating the environmental impacts of global lithium ion battery supply chain: A temporal, geographical, and technological perspective. *PNAS Nexus*, 2(11), pgad361.

<https://academic.oup.com/pnasnexus/article/2/11/pgad361/7451193>

Mining that fuels the global transition to renewable energy may threaten Indigenous communities | Mott Foundation. (2025, April 9). Mott Foundation. <https://www.mott.org/news/articles/mining-that-fuels-the-global-transition-to-renewable-energy-may-threaten-indigenous-communities/>

Owen, J.R., Kemp, D., Lechner, A.M. *et al.* Energy transition minerals and their intersection with land-connected peoples. *Nat Sustain* 6, 203–211 (2023). <https://doi.org/10.1038/s41893-022-00994-6>

- Putsche, V. L., Pattany, J., Ghosh, T., Atnoorkar, S., Zuboy, J., Carpenter, A., Takeuchi, E. S., Marschilok, A. C., Takeuchi, K. J., Burrell, A., & Mann, M. K. (2023). A framework for integrating supply chain, environmental, and social justice factors during early stationary battery research. *Frontiers in Sustainability*, 4. <https://doi.org/10.3389/frsus.2023.1287423>
- Truong, C. N., Naumann, M., Karl, R. C., Müller, M., Jossen, A., & Hesse, H. C. (2016). "Economics of Residential Photovoltaic Battery Systems in Germany: The Case of Tesla's Powerwall." *Batteries*, 2(2), 14. <https://go.exlibris.link/1St3w2mW>
- United States of America. (2021). An Act To ensure that goods made with forced labor in the Xinjiang Uyghur Autonomous Region of the People's Republic of China do not enter the United States market, and for other purposes. In *Public Law* [Legislation].
<https://www.govinfo.gov/content/pkg/PLAW-117publ78/pdf/PLAW-117publ78.pdf>
- U.S. Department of Energy. (2020, December). *Energy Storage Grand Challenge Roadmap* (DOE/PA-0022). <https://www.energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Grand%20Challenge%20Roadmap.pdf>