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The Battery Storage Delusion: *Utility-Scale Batteries Are No Silver Bullet*

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The Issue

Utility-scale lithium-ion battery energy storage systems (BESS), together with wind and solar power, are increasingly promoted as the solution to enabling a "clean" energy future.[1] Advocates argue that batteries can store surplus power from wind and solar generation and discharge it when needed.[2] As a result, governments, utilities, and investors have directed billions of dollars toward utility-scale battery installations worldwide.

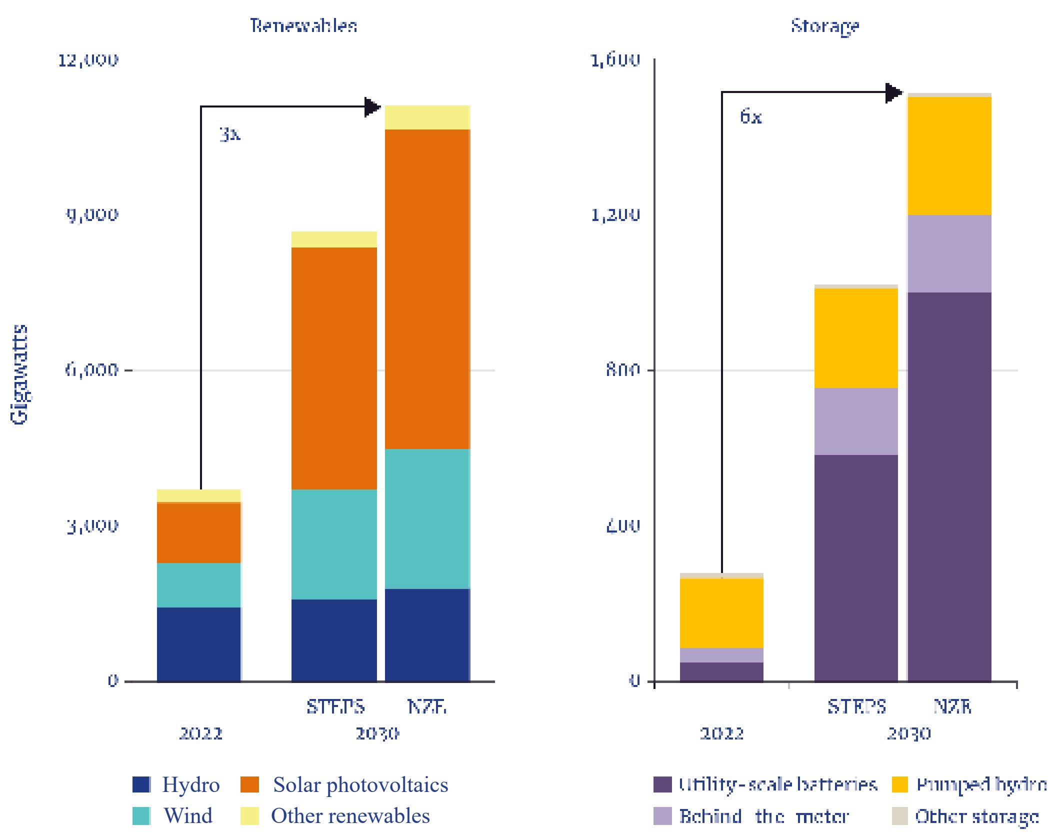
This growing reliance on battery storage reflects an intriguing narrative: that batteries can resolve the intermittent and weather-dependent aspects of wind and solar and significantly reduce, if not eliminate, the need for fossil fuels in power generation. Yet this enthusiasm often overlooks the physical and economic realities of the lithium-ion battery storage technology that is currently in use. While batteries can provide valuable short-term support to the grid, they cannot function as long-duration energy storage (LDES) solutions or scale to the levels needed to back up large-scale energy systems that are reliant on intermittent wind and solar.

By focusing on utility-scale batteries as a viable solution for a "renewable" energy future, policy discussions risk overlooking critical technical, material, and life-cycle constraints. Without a clear understanding of these limits, investments and regulations could undermine energy reliability and security while misallocating and depleting raw materials, energy, finances, and other resources—thereby intensifying the environmental pressures that batteries are intended to alleviate and diverting much-needed investment in peak-power-capable, dispatchable energy generation infrastructure toward short-term, energy-consuming storage infrastructure.

> The capacity of an energy storage system should be expressed in units of energy (gigawatt hours, or GWh) rather than by its power rating (GW), since batteries can supply power only until their stored energy is depleted. A multiplier of four is often applied; for example, a 1-GW power rating would correspond to 4 GWh of storage capacity, assuming a four-hour duration and no losses. However, a multiplier of 2.5 more accurately reflects the average utility-scale storage duration, based on the ratio of manufacturers' stated storage capacity (GWh) to power rating (GW).[3]

Figure 1

Forecast Capacity Additions: Renewable Generation and Storage



Notes: STEPS refers to IEA's Stated Policies Scenario. NZE Scenario is IEA's Net Zero Emissions by 2050 Scenario. Other "renewables" include bioenergy, geothermal, concentrating solar power, and marine energy. Other storage includes compressed air energy storage, flywheel energy storage, and thermal energy storage. Hydrogen electrolyzers are not included.

Source: Adapted from Oskaras Alšauskas et al., *Batteries and Secure Energy Transitions* (International Energy Agency, 2024), fig 2.1, 68. This is a work derived by NCEA from IEA material, and NCEA is solely liable and responsible for this derived work. The derived work is not endorsed by the IEA in any manner.

The Reality

Utility-scale batteries are not long-duration, dispatchable power sources; they are energy sinks that carry significant economic and environmental costs. Most are designed to store chemical energy that can be extracted as electrical energy for one to four hours.[4] A 400-MW battery system with a four-hour duration provides, in theory, 1,600 MWh of stored energy. In contrast, a 400-MW gas plant can operate almost indefinitely—if fuel is available. Batteries cannot deliver power continuously and must be recharged, often via the same intermittent power they were meant to buffer. They do not provide reliable backup.

Efficiency is frequently overstated. Manufacturers often cite round-trip efficiencies of 85% or higher, yet field data suggest that real-world efficiency is closer to 70% due to inverter losses, thermal management, control systems, and auxiliary loads.[5,6]

Battery life span and degradation further compound these limitations. Most lithium-ion batteries—currently the dominant chemistry for utility-scale systems—last for 10 to 13 years and degrade by 3% to 7% annually.[7] Systems regularly require partial module replacements after six to eight years.

The scale required for sufficient backup is staggering. A single 1-GWh battery installation requires roughly 700,000 tons of mined, processed, and transported raw materials and consumes approximately 450 GWh of energy to manufacture—450 times its rated gross storage capacity—when the entire system and life cycle are taken into account.[8]

Utility-Scale Batteries: Fact Sheet

Energy density & lifetime of utility-scale batteries

- 140–180 Wh/kg ⇛ energy density at cell-level making up ~25% of total BESS weight
- 100 Wh/kg ⇛ energy density at system level (generously overestimated)
- Lifetime 10–13 years on average. Real-life round-trip efficiency of utility-scale solar = realistically about 75%–85%
- Deteriorates by 3%–7% p.a.
- Recommended battery use range = 20%–80%, meaning only about 60% of the nameplate capacity is usable on a daily basis

Environment

1-GWh utility-scale lithium-ion battery system is equivalent to the explosive potential of nearly 900 tons of TNT

- With potential for large explosions, fires, and clouds of toxic gas
- Illegal exports and dumping in Africa are realistic
- Recycling batteries is likely to make a smaller long-term contribution than expected, partly because LFP has little recycling value (no cobalt or nickel)

Costs & supply chains

- 470 USD/MWh*; assume 40% improvement and use ~250 USD/kWh
- Realistically a 4-hour lithium-ion LFP utility-scale battery system all-in costs (not price quoted) in 2024 to 2025 **ranges ~150–250 USD/kWh**
- China controls ~90% of battery cell component manufacturing (anodes, cathodes), ~80+% of battery cell manufacturing, and majority of raw material processing for batteries

1-GWh utility-scale battery capacity (uncharged)

- Weighs about ~10,000 tons
- Requires ~0.7 Mt of ores and raw materials
- Needs ~450 GWh of "input energy to be invested"

* As per "Utility-Scale Battery Storage," 2024 Annual Technology Baseline, National Renewable Energy Laboratory, https://atb.nrel.gov/electricity/2024/utility-scale_battery_storage; see also BloombergNEF, "Global Energy Storage Growth Upheld by New Markets," BloombergNEF, June 18, 2025, https://about.bnef.com/insights/clean-energy/global-energy-storage-growth-upheld-by-new-markets, which reported a U.S. energy storage cost of 200 USD/kWh, excluding engineering, procurement, and construction (EPC) and grid connection costs.

Source: Adapted from Lars Schernikau, "Pros and Cons of Utility-Scale Battery Storage," *The Unpopular Blog*, July 25, 2025, https://unpopular-truth.com/2025/07/25/pro-and-cons-of-utility-scale-battery-storage/.

For Germany, in the absence of dispatchable generation or electricity imports, maintaining sufficient battery backup during a typical winter day (i.e., 60 GW sustained over 24 hours) would require approximately 1.9 TWh of utility-scale lithium-ion batteries, assuming 75% net round-trip efficiency. Producing this capacity would entail roughly 1.3 billion tons of materials and approximately 850 TWh of input energy; this cycle would need to be repeated about every 10 years, if battery life span is optimal.[9,10,11] Scaling this technology to national levels would demand billions of tons of material extraction and thousands of TWh of up-front energy investment, most of it derived through fossil fuels. That raises serious questions about whether solar- or wind-power systems with battery backup are truly better for the environment.

Safety risks also increase with scale. The stored energy in larger 1-GWh lithium-ion systems is comparable to hundreds of tons of TNT, and thermal runaway events have caused fires and explosions in battery facilities, ships, and aircraft. The larger and more densely packed these systems become, the greater the risk.[12]

Battery recycling is often suggested as a solution to the environmental disposal burden of large-scale energy storage, but the numbers indicate otherwise. Recycling is five to 10 times less energy-intensive than producing new batteries, but most utility-scale batteries currently deployed will not even reach the end of their service life before 2035, delaying theoretical recycling benefits for years.[13] Furthermore, lithium iron phosphate (LFP) batteries, which dominate utility-scale deployments, lack the higher-value cobalt and nickel that traditionally drive battery recycling economics. Instead, LFPs consist primarily of iron, lithium, phosphate, and graphite—materials that have significantly lower market value, making large-scale recycling less financially attractive and less likely to be implemented.

Regulatory environments for waste handling also vary widely, which can exacerbate environmental risks. Europe and China enforce strict regulations against improper disposal within their territories, but countries such as India and the U.S. have weaker enforcement. These inconsistent regulations have led to growing concerns about battery waste being transported across borders. Dumping in parts of Africa is common, and exporting waste beyond national territories appears to be allowed even in Europe and China. The environmental and human toll of such dumping is largely externalized by shifting the consequences elsewhere.

Perspectives

Policymakers and regulators must reconsider their expectations regarding what utility-scale batteries can realistically deliver. Batteries provide value in specific grid applications—particularly for frequency regulation, voltage support, and bridging short-term supply gaps—but they do not transform wind and solar installations into reliable, dispatchable power plants.[14]

Rather than expanding short-duration battery storage to compensate for weather-dependent generation, energy strategies should prioritize firm, electricity-generating, peak-power-capable, dispatchable capacity that ensures power availability even during extended periods of low wind and sun, known as *Dunkelflaute* (a German term for the “dark doldrums”).

The narrative that batteries can solve the intermittency problem at scale is not only technically flawed but also misleading, as it diverts attention from the development of power systems that actually generate—rather than consume or partially store—electricity and that are more robust, realistic, and cost-effective. Reliance on short-duration batteries as a core solution risks increased electricity shortages and higher energy costs.

Utility-scale batteries can enhance grid stability—but they are not a scalable or sustainable solution to overcome the intermittency of wind and solar. Policymakers should prioritize investment in proven, dispatchable energy systems while supporting research into emerging technologies, including long-duration energy storage (LDES) systems that are both economically viable and environmentally sustainable. ■

Notes

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13 Schernikau, "Pros and Cons."

14 Schernikau, "Pros and Cons."

ABOUT THE AUTHOR

Lars Schernikau has more than two decades of experience in the energy and commodities industry. His journey began at Boston Consulting Group in the U.S. and Germany from 1997 to 2003, which shaped his deep understanding of global coal, ore, and steel markets. His experience also includes managing a wind farm in Germany for three years. As cofounder, shareholder, and former supervisory board member of HMS Bergbau AG and IchorCoal NV—international commodity marketing and mining companies—Schernikau is a renowned energy industry expert and keynote speaker at energy and commodity forums worldwide. He advises governments, banks, educational institutions, and corporations on macro and energy economics and shapes energy policy. His latest book, *The Unpopular Truth About Electricity and the Future of Energy*—coauthored with William Hayden Smith—deals with the energy economics of the proposed "energy transition" away from oil, coal, and gas to wind and solar combined with storage and hydrogen. Schernikau has also authored books on coking coal and thermal coal.

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