POLICY NOTE

STRATEGIC ENERGY RESERVES IN THE ERA OF ELECTRIFICATION

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Abstract

Traditional strategic petroleum reserves, while necessary instruments for short-term supply shock mitigation, are structurally insufficient for the evolving anatomy of energy security in an electrifying global economy. The accelerating pivot towards electricity-centric energy systems redefines vulnerability. Chokepoints increasingly manifest across supply chains encompassing critical minerals, diverse fuel types, and their financing, not solely crude oil logistics. Unrefined petroleum stockpiles must be accordingly reconceptualized as one component in a portfolio of storable buffers distributed across multiple interconnected vectors capable of addressing shocks to both stocks and flows of energy.

A robust analytical framework for comprehensive energy security should evaluate assets against three diagnostic criteria: physical storability, geographic concentration of production and cascading sectoral impact. Crude oil, refined products, natural gas, coal and nuclear fuel satisfy the storability condition while exhibiting marked geographic concentration.[1] Electricity, by contrast, demands instantaneous delivery as it cannot currently be effectively stored in bulk, shifting analytical emphasis from stockpile adequacy to flow continuity and systemic resilience. Relative to centralized electricity systems, distributed systems can reduce exposure to targeted disruption, strengthen adaptive capacity against non-conventional threats, and provide redundancy under conditions of unpredictable shock.

Reserve portfolio maintenance imposes substantial capital and operational costs, encompassing acquisition, storage infrastructure, carrying costs, and opportunity costs, each entailing complex trade-offs between physical security, fiscal affordability, and market flexibility. G20 member states are institutionally positioned to design innovative financing mechanisms that enhance affordability and accessibility of reserve portfolios for developing economies. Regional reserve-sharing arrangements among states with correlated, but not perfectly synchronous supply disruption risk can offer security coverage at lower aggregate cost through risk diversification and infrastructure economies of scale. Private-sector co-financing via government-guaranteed reserve investment vehicles can further mobilize capital, enabling regulated private returns on state-mandated reserve assets and relieving sovereign balance sheet pressure without compromising strategic objectives.

[1] Developing strategic gas storage would demand suitable geology or LNG imports, face multi-year development timelines, and likely need to be built upon existing commercial capacity. See for example, Gas Reserve Mechanisms and Flexibility Options - Enhancing gas supply security in a changing global market

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Introduction

1. The new anatomy of energy vulnerability

The world's energy mix is still heavily dominated by fossil fuels, and traditional energy security frameworks remain largely focused on volumetric oil and gas supply shocks, such as the blockade of the Strait of Hormuz. However, many countries are engaged in electrification to lessen their dependency on oil and gas imports and/or to reduce greenhouse gas emissions. This transition to an electrified economy does not eliminate energy insecurity; instead, vulnerability compounds beyond concerns about fuel availability to the increasing criticality of the resilience of electricity grids and the mineral supply chains that support them.

First, a highly electrified system introduces vulnerabilities that can occur at different temporal and spatial scales. In a fossil fuel framework, supply buffers often include highly durable physical storage. In contrast, an electrified system requires continuous real-time balancing of supply and demand. Fossil fuels remain relevant, however, particularly in systems where gas-fired plants provide balancing services; but in the future, these functions are expected to be increasingly performed by storage technologies such as batteries, which typically provide much shorter-duration reserves. Long-duration energy storage technologies besides pumped hydro still need to be developed at scale.

Second, vulnerability is displaced from oil and gas systems to the mineral extraction and refining sectors. Electricity security will increasingly depend on the procurement of critical minerals, which are essential for the manufacturing of many parts of the electricity system. Because the refining capacity for these critical minerals is highly concentrated geographically, a geopolitically driven embargo would delay the electrification of importing countries, even though it would have limited immediate effects on electricity supply.

Third, an electrified energy system is particularly exposed to cyber-attacks, due to its reliance on millions of smart meters, inverters, and automated demand-response mechanisms. This makes it possible for cyberattacks to collapse national or regional grids instantaneously. In particular, cyber-physical attacks targeting key system components can inflict physical damage, leading to sustained disruptions.

As a result, the transition to electrification is reshaping the geography and nature of energy vulnerability, shifting it from a focus on fuel supply disruptions toward risks embedded in networks, materials, and digital infrastructures.

2. Three diagnostic criteria

A robust analytical framework for comprehensive energy security should evaluate energy assets against three diagnostic criteria: physical storability, geographic concentration of production, and economic disruption potential. Crude oil, refined petroleum products, natural gas, coal, nuclear fuel, and some critical minerals satisfy the storability condition while exhibiting marked geographic concentration. Oil, natural gas and coal contributed over 86 percent of primary energy supply in 2025, indicating that fossil fuels are likely to remain the predominant focus of strategic storage in the immediate term.[2] The blockade of the Hormuz

[2] Energy Institute, "Statistical Review of World Energy 2026," Energy Institute, https://www.energyinst.org/statistical-review

Strait has raised questions over the adequacy of IEA (International Energy Agency) members' strategic crude stocks.[3] Not only was the IEA stock release of 400 million barrels too small relative to the size of the shock, but it was also regionally mismatched and ill-suited in crude quality or product type to offset volumetric loss.[4]

Developing Asia, which was one of the worst affected regions by the closure of the Strait of Hormuz, effectively shifted the burden of adjustment to demand, employing price controls, rationing and policy interventions designed to accelerate the substitution of petroleum products with biofuels and electrification. Affordability constraints that limited Asian economies' access to scarce LNG (liquefied natural gas) cargoes during the blockade of Hormuz could prompt a reassessment of the long-term role of LNG relative to renewables, nuclear and even coal.[5] These dynamics, in turn, raise critical questions over justifying new large-scale investments in strategic crude reserves by developing countries.

The race to access reliable, firm, carbon-free baseload power to meet electricity demand for data centers and artificial intelligence (AI) computing power has revived strong interest in nuclear energy. Unlike strategic stocks of crude and natural gas that have a large spatial footprint, nuclear fuel can be stockpiled with a relatively modest spatial footprint due to its high energy density. However, strategic vulnerabilities also lie in uranium production and the conversion and enrichment phases, which are heavily monopolized by select geopolitical actors. For States lacking domestic enrichment infrastructure, stockpiles of natural uranium provide limited strategic utility. In contrast, inventories of enriched uranium necessitate robust physical security, stringent regulatory safeguards and sustained international oversight to eliminate risks of diversion or theft.

Critical minerals required by most clean energy technologies and grid infrastructure are supply constrained, with high concentration risk in processing. Physical stockpiling is feasible for some (metals) but challenging for others due to degradation or processing needs. Critical minerals vary by grade, chemistry, and application. Rapid technological shifts (say, in battery chemistry) risk rendering stockpiled material obsolete.

A key challenge is that strategic mineral reserves cannot be separated from industrial policy. Unlike oil, where a barrel of oil stored today remains largely unchanged in volume and, to a certain extent, value for years, critical minerals derive their value from their role in the industrial ecosystem. Stockpiling lithium alone provides limited resilience if battery manufacturing remains concentrated elsewhere. Similarly, rare earth inventories offer limited protection if refining and magnet production are concentrated in different regions. Critical mineral stockpiling policies must therefore be integrated with domestic processing and manufacturing.

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[3] Equivalent to 665 days of IEA member countries net imports in 2025 (including strategic stocks held by net oil exporters), IEA; however, this is only equivalent to 3 to 4 days of global oil consumption.

[4] Fattouh, Bassam & Andreas Economou, "The Strait of Hormuz Oil Shock: Features and Implications," Issue 149, May 2026, "Unpacking the Hormuz Crisis: Implications for Energy Markets and the Energy Transition," Forum, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/publications/unpacking-the-hormuz-crisis-implications-for-energy-markets-and-the-energy-transition-issue-149/

[5] Fulwood, Mike, "Hormuz Closure Impact on LNG: Keep Calm and Carry On," Oxford Institute for Energy Studies, 2026, https://www.oxfordenergy.org/publications/closing-the-strait-of-hormuz-impact-on-the-global-gas-marke

Electricity is distinguished by its requirement for instantaneous delivery, as it cannot, currently, be effectively stored in bulk.[6] This shifts analytical emphasis from stockpiles to continuous flows. Grid disruptions driven by frequency or voltage collapse or imbalance between supply and demand can precipitate immediate blackouts. Establishing a grid component reserve that includes transformers, mobile substations, valves, battery inventories, and other resilience-enhancing equipment could become part of strategic storage to facilitate rapid restoration of grid functionality.

Still, strategic reserve policy for power systems needs to include two aspects: temporal balancing assets to manage power supply/demand imbalances and physical hardware reserves to maintain system integrity. Indeed, operational reliability requires a tiered suite of dynamic balancing assets calibrated to specific time domains: battery reserves to address contingencies lasting seconds to minutes; pumped hydro storage or equivalent for disruptions spanning hours to days; and in the future, zero-carbon dispatchable capacity or green fuels to bridge multi-week seasonal shortfalls.

In contrast, strategic mineral stocks, nuclear fuel stockpiles, and fossil fuel supply security serve a different function: shielding energy infrastructure manufacturing and fuel import channels from geopolitical shocks. One priority for the G20 could be the broadening of strategic energy reserves beyond crude oil to encompass refined petroleum products, natural gas, nuclear fuel, critical minerals, and essential components of emerging energy technologies.

3. Centralized versus distributed resilience

The war in Ukraine and the recent conflict in the Middle East have both demonstrated that large energy assets, such as pipelines, LNG export terminals, refineries, and large power plants, are particularly vulnerable to physical attacks and disrupted access. The resilience of an electrified grid increasingly requires energy systems that are modular and distributed, allowing them to coexist with centralized assets that currently form the backbone of most electricity systems.

Distributed resilience leverages the decentralized nature of microgrids to create modular, bottom-up survivability. By utilizing localized microgrids and virtual power plants that aggregate decentralized clusters of distributed energy resources (such as rooftop solar, backup generators, EV chargers, and battery storage), the energy system can, where islanding capabilities are available, continue operating autonomously during a disruption. If a cyber-attack or extreme weather event impacts the main grid, these distributed assets allow critical sites such as hospitals, military bases, and water utilities to operate independently. This localized autonomy reduces the risk that localized disturbances propagate into wider regional outages.

Integrating these distributed assets into the wider energy framework also requires a complete rethinking of strategic energy reserves. Historically, these have been large, centralized

[6] At present, the physical and economic constraints of battery chemistry and capacity prevent the bulk storage of electricity for extended periods. Nevertheless, ongoing innovation in long-duration energy storage, including next-generation solid-state batteries, green hydrogen, compressed-air storage, power-to-gas systems and advanced pumped hydro, indicates that viable, large-scale storage solutions are likely to emerge in the coming decades.

stockpiles of physical fuels injected into markets to offset immediate volumetric supply shocks. In an electrified future, this centralized defensive architecture must evolve to complement localized, distributed resilience. In the event of a disruption involving cyber-physical strikes that destroy critical infrastructure, these centralized reserves would take the form of stockpiles of strategically important equipment, including standardized transformer components and other long-lead-time grid hardware. In contrast, sovereign stockpiles of critical minerals are more long-term in nature, and serve as a hedge against geopolitical constraints on grid expansion and electrification strategies.

Ultimately, the optimal energy strategy is not a binary choice between centralized and decentralized architectures. Resilience will emerge not from any single technology or infrastructure model, but from the deliberate integration of centralized redundancy and decentralized adaptability across the energy system.

4. The financial dimension

Maintaining a strategic energy reserve portfolio with a wide range of heterogeneous components is a capital- and operationally expensive exercise. Apart from acquisition costs of the energy source, minerals, and technology components, there are storage and infrastructure costs, carrying costs, operational costs, and opportunity costs involving complex trade-offs between physical security, fiscal stability, and market flexibility. Critical minerals carry the highest per-unit carrying cost relative to their energy security contribution because their value is embodied in future manufacturing throughput rather than directly in energy delivery.[7] This creates a distinctive financing problem: the security benefit of a critical mineral reserve is diffuse, long-dated, and difficult to monetize while the cost is immediate and concentrated. Prioritization of investment in innovative cooperative frameworks and public–private cost- and risk-sharing mechanisms could be encouraged by the G 20 to assist in reducing the financial burden associated with the maintenance of strategic energy reserves

Developing countries face a compounding set of structural disadvantages in reserve economics that transform what is a manageable fiscal burden for IEA members into a potentially prohibitive one for most developing countries. The G20, one of the most economically heterogeneous multilateral forums encompassing member states with markedly divergent income levels and developmental trajectories, can design a comprehensive suite of innovative financing mechanisms to improve access to strategic energy storage.

Public-private partnerships offer one solution to the affordability challenge. Private sector co-financing through strategic reserve investment vehicles can mobilize capital for the reserve assets through government-guaranteed instruments, with private investors earning a regulated return on reserve assets they hold on behalf of the state. Rather than governments purchasing and holding inventories directly, reserve obligations can be distributed among refineries, utilities, mining companies and other actors in the energy production and delivery value chain. This will embed strategic energy stocks within the commercial supply chain, reducing fiscal burden while preserving emergency access. India’s mandatory stock obligation framework for refineries is a partial model, and the EU’s ticket system is a more

[7] Altiparmak, Suleyman Orhun, “China and Lithium Geopolitics in a Changing Global Market,” *Chinese Political Science Review*, 1-20, 25 Aug 2022, https://pubmed.ncbi.nlm.nih.gov/40479253/

advanced system for burden sharing.[8] The principal risk in this model is that private holders will under-invest in reserves, which makes robust regulatory monitoring necessary.

Experience from Asia and Africa demonstrates that governance deficits pose a more significant constraint than financial limitations in regional cooperation for energy storage. This underscores a potential role for the G20 forum to coordinate the structured management and release of shared energy storage, which includes sharing best practices on the most efficient ways for each member state to do its part.

Electrification may offer developing countries a partial escape from the burden of maintaining petroleum reserves if they can leapfrog to a predominantly renewables-based energy system. But in the absence of domestic critical mineral reserves with processing and manufacturing capacity for clean energy technologies, challenges to maintain reserves may be transformed and intensified into a new burden, as clean energy supply chains are more concentrated than petroleum supply chains.

Conclusion

In an electrifying global economy, security risks arise from interconnected chokepoints. The next generation of strategic energy reserve policy should therefore be conceptualized as a strategic energy system resilience framework rather than a strategic petroleum reserve framework. Identifying and assessing energy assets according to physical storability, geographic concentration of production, and economic disruption potential could be a useful framework. The G20 forum should consider actions to modernize strategic petroleum reserves along three tracks: (i) Initiate expansion of the energy reserve portfolio beyond crude oil by including refined petroleum products, natural gas, nuclear fuel, critical minerals, and other energy technology components; (ii) Invest in developing and fostering innovative co-operative and public-private cost and risk-sharing arrangements for maintaining strategic energy reserves; and (iii) Develop coordination of sharing and release mechanisms for stockpiles of natural gas, critical minerals, and other energy components to reduce costs while improving resilience.

[8] Tickets are stockholding arrangements under which the seller agrees to hold (or reserve) an amount of oil on behalf of the buyer, in return for an agreed fee. The buyer of the ticket (or reservation) effectively owns the option to take delivery of physical stocks in times of crisis, according to conditions specified in the contract, https://www.iea.org/data-and-statistics/data-tools/oil-stocks-of-iea-countries