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Five Key Decisions to Revitalize US Critical Mineral Stockpiles

By **Dr. Tom Moerenhout, Cina Vazir**, and **Irina Patrahau**
July 2025

REPORT

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He has advised and consulted for various stakeholders, including the White House, Departments of Energy and State, USTR, and policymakers in several other countries, including the EU, Canada, India, Indonesia, Nigeria, DRC, Egypt, Iraq, Chile, and Brazil. His collaborative efforts span organizations such as the OECD, IEA, World Bank, UNCTAD, UNEP, OPEC, IRENA, and several philanthropic foundations.

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Executive Summary

The United States is at a pivotal moment to modernize its approach to critical mineral stockpiling. Minerals are increasingly central to American strategic interests, yet the US remains heavily reliant on foreign suppliers, particularly China, for processed materials. This dependency exposes the US to major vulnerabilities in national, economic, and climate security. The National Defense Stockpile (NDS) can be a key policy lever to reduce these vulnerabilities. At present, however, the NDS is underfunded, covering only a fraction of projected needs in a national emergency. It also may not be realizing its potential to address underlying market failures that threaten US economic interests in addition to its historical defense role.

This report, part of the Critical Materials Initiative at the Center on Global Energy Policy at Columbia University SIPA, finds that an economic stockpile with market-shaping quantities of material may cost more than six times the amount of a defense-oriented stockpile. It is therefore important to integrate stockpiling choices into the wider array of policy options, analyzing whether a stockpile is the most efficient tool to address the specific market failure at hand for each material and transaction.

The report outlines five foundational choices if a stockpiling strategy is adopted, as bipartisan support suggests is possible, and offers related recommendations for US policymakers designing such a system:

1. **Clarify the stockpile objectives:** The United States would need to decide whether its stockpile would serve national defense exclusively or also aim to stabilize markets and support key industries. International examples from China, Korea, and Japan show that it is possible to serve dual interests. A wider mandate for the NDS could expand its objectives to include reducing price volatility, supporting responsible supply chains, and de-risking capital investment.
2. **Choose which minerals to stockpile:** The US currently uses lists from the US Geological Survey, Department of Energy, and Department of Defense to determine which materials are critical and potentially worth stockpiling. It is crucial to regularly align and update these lists. A tiered approach could distinguish between bulk/base metals, battery materials, and niche metals (for which high-impact, low-cost opportunities exist). It can also phase acquisitions to avoid distorting markets and inflating acquisition costs.
3. **Decide which processing stage to stockpile for each mineral:** Stockpiling ores offers flexibility but assumes domestic processing and refining capacity that the US lacks for most minerals.

Refined products, despite higher costs and storage complexity, are more useful in times of crisis. The US could prioritize stockpiling refined products in the short term while accelerating investments in allied processing infrastructure.

4. **Formalize the management system:** Stockpiles can be managed by the federal government, semi-independent agencies, or private industry under mandate—or some mix of the three. Korea and Japan use hybrid models, combining public stockpiles with voluntary or mandatory private reserves. The US can adopt a similar structure that balances public control with industry participation, including the use of offtake contracts and emergency release mechanisms.

5. **Weigh stockpile costs against depth:** Acquisition costs will rise significantly as global demand for minerals increases. Strategic use of instruments like forward contracts, contracts-for-difference, and advance purchase agreements can help manage costs for a market-shaping stockpile while still incentivizing new supply.

The US would need to ensure that the NDS is properly funded to meet its current mandate before considering expanding its scope to industrial resilience and economic security, which would require additional sustained investment over decades rather than a one-off appropriation. But the country does face an important window to align mineral stockpiles with the strategic landscape of the 21st century. A well-designed system can reduce supply chain vulnerabilities, support domestic and allied industries, and enhance America's geopolitical leverage.

Introduction

Critical mineral[1] stockpiles are emerging as a key area of bipartisan support among US policymakers. The first Trump administration increased the stockpiling of rare earth elements and considered using stockpiles to support domestic mineral producers.[2] Similarly, Democrats have long recognized the need to update critical mineral stockpiles.[3] With President Donald Trump back in office, and the Democratic Party supportive of critical mineral industrial policy, the United States has a key window of opportunity to modernize its mineral stockpiling system.

The US National Defense Stockpile (NDS) has historically played an important role in ensuring sufficient mineral supplies for national defense purposes but is no longer sufficiently funded to support either defense or commercial objectives.[4] The mandate of the NDS is also in question; new authorities or a more aggressive use of existing authorities would be required for the NDS to play a larger role in diversifying critical mineral supply chains. Policymakers are indeed debating whether stockpiles should have a mandate to focus not just on defense but also on security of supply more broadly, but recent stockpiling discussions have only scratched the surface of the formidable challenges of designing and implementing such systems.

A discussion of mineral stockpiling is important for two reasons, and centers around the vulnerability of key sectors of the US economy to supply chain restrictions.[5] First, the development of mining projects requires significant lead times, easily more than 16 years,[6] which makes mineral supply inelastic in the near term. If there is a market disruption, new supply takes years to develop, and that can threaten downstream markets. Second, China dominates most mineral supply chains, particularly in processing minerals to the purities needed for energy, digital, and defense applications. This dominance provides China with leverage to influence global markets through supply restriction or price manipulation. Chinese primacy is expected to continue through 2040, adding pressure to other governments to secure their own mineral supplies.[7]

US policymakers face nuanced trade-offs when deciding whether and how to establish a stockpiling system. This report outlines five key choices to guide a new material stockpiling system in the United States and discusses how these choices have already been made in China, South Korea, and Japan. The five principal choices analyzed in this report involve the following:

1. Primary and supporting objectives of the stockpiling system
2. Critical minerals to stockpile
3. Processing stage of critical minerals to stockpile

4. Management system
5. Trade-offs between costs and stockpile depth

The report begins by providing context to understand the perceived need for mineral stockpiling before elaborating on the five choices mentioned above. It then summarizes the decisions made by existing stockpiling regimes in China, South Korea, and Japan on these parameters and concludes with recommendations for US policymakers.

Five Choices to Define a Stockpile

Choice 1: Primary and Supporting Objectives of the Stockpiling System

The first and foremost objective of stockpiling is to ensure a steady supply of material in times of disruption. However, a stockpiling system can also support several other strategic objectives. It is essential for policymakers to define a stockpile's objectives, since these will determine the stockpile's design, costs, and impact on the market.

Primary Objective: Defense or Economic Stockpile?

Over the last century, American policymakers, industry members, and citizens have vigorously debated whether US stockpiles should focus on disaster response and national defense or have a wider commercial mandate to influence prices and markets. The resolution of this debate forms the basis of any stockpiling system.

1. **National defense stockpiles** include materials used in military technologies, weapons systems, and advanced defense equipment. These stockpiles generally have narrow mandates with strict boundaries. Stockpile managers, along with other government agencies, evaluate national needs under different scenarios. They then stockpile the necessary quantity of material to provide sufficient buffers in the case of a national supply disruption. The quantity of required material is only meant to cover needs of the defense sector, and stocks are typically released only in the case of a serious emergency. Stockpile managers are directed to make acquisitions and disposals based on need versus trying to "time" the market.[8]

2. **Economic stockpiles** are created to actively help manufacturers manage supply chain risks and influence markets. Such stockpiles are meant to stabilize markets and allow strategic sectors to continue operating during supply shortages. Relevant sectors are not limited to defense but include energy and the digital economy. An economic stockpile can also affect markets by using acquisitions and disposals to influence prices. For example, a stockpile could purchase more material to increase demand and raise prices. Or it could do the reverse, releasing material to help lower prices in the domestic or global market.

   Arguments for economic stockpiles have recently gained prominence due to concerns that nonmarket forces are hindering the economic resilience of key industries in the United States, for example by flooding the market with supply so that prices decrease and US companies can no longer be profitable.[9] An economic stockpile may respond through a variety of measures, including securing supply for domestic companies, using offtake agreements to send demand signals, or directly using acquisitions and disposals to influence prices. While private stockpiles already exist, the government may be better positioned to manage an economic stockpile because it has the advantage of scale and can factor for externalities like geopolitical competition, responsible mineral production, and strengthening domestic industries.

The debate around defense versus economic stockpiles cannot be separated from the debate about the role of government intervention in private markets. Should governments actively intervene in shaping the prices of economic goods? Is active industrial policy an appropriate use of taxpayer money, or does it unduly transfer wealth to certain companies at the expense of taxpayers? Is it acceptable for the government to selectively intervene when certain economic sectors are suffering but stand by at other times? These are challenging questions, and they undoubtedly shape the discourse and political feasibility of economic stockpiling.

In the US, stockpiles have generally tilted toward emergency response and national defense. The US currently maintains various stockpiles for disaster response, including the Strategic National Stockpile that stores more than $8 billion in medical supplies and equipment to respond to public health emergencies; food and crop stockpiles managed by the US Department of Agriculture for food aid programs and crop emergencies; and Federal Emergency Management Agency stockpiles of food, water, generators, and other materials for response to national emergencies. Emergency response stockpiles are primarily focused on providing relief in cases of national disaster and do not seek to influence private markets.

Similarly, the US NDS focuses exclusively on national defense and emergency response. The NDS is managed by the US Defense Logistics Agency and is the primary US stockpile of critical minerals. According to its mandate, "the NDS is a strategic stockpile, not an economic stockpile. It is not intended to influence prices in the market or insulate private industry from supply shocks."[10]

Prior to declaring this mandate in 1987, the NDS faced decades of criticism over its acquisitions and disposals.[11] These decisions were seen by some to excessively affect market prices and economic behavior. For example, in 1976, the American Mining Congress testified to Congress that the stockpile had "an extremely disruptive influence in the market for metals and minerals" and that mining industry CEOs "would just as soon have no [national] stockpiles at all."[12] It is important to put these critiques in the context of their time, which was one of increased trade openness and liberalization, together with a drawdown of industrial policy.

Since then, the global economic and geopolitical landscape has changed considerably. As policymakers consider the future of US stockpiles, they face a world in which national defense does not simply consist of access to inputs for defense technologies but encompasses energy security and competitiveness in industries of the future. These variables are increasingly tied to critical minerals.

As US policymakers reimagine critical mineral stockpiles, they will need to adopt a nuanced view of the relationship between national defense and economic security. The decisions between the two are not binary. Policymakers have a spectrum of options to meet the near-term needs of the defense base while selectively intervening in private markets to pursue a broader vision of long-term national security. An optimal system may also include different designs for different groups of critical minerals.

Case Study #1: US NDS

The NDS underwent significant expansion after World War II with the emergence of the Cold War. US policymakers saw stockpiles as a crucial measure to enhance emergency preparedness and deterrence, and by 1952, the NDS held approximately $47.5 billion (2024 dollars) in material.[13] By the end of the Cold War in 1989, the NDS inventory value had declined to about $24 billion (2024 dollars). (See Figure 1.)

When the Cold War ended, the Defense Department estimated that over 99 percent of the NDS was not needed, and Congress authorized its disposal.[14] The US was entering a more unipolar world, and American policymakers increasingly believed the country and its allies could enjoy a new "peace dividend" by redirecting defense spending to other areas of the economy.[15]

The NDS has continued to shrink. As of March 2023, the US material stockpiles were estimated at $912 million (2023 dollars),[16] or about 2 percent of the inflation-adjusted value of inventory in the stockpile in 1952.

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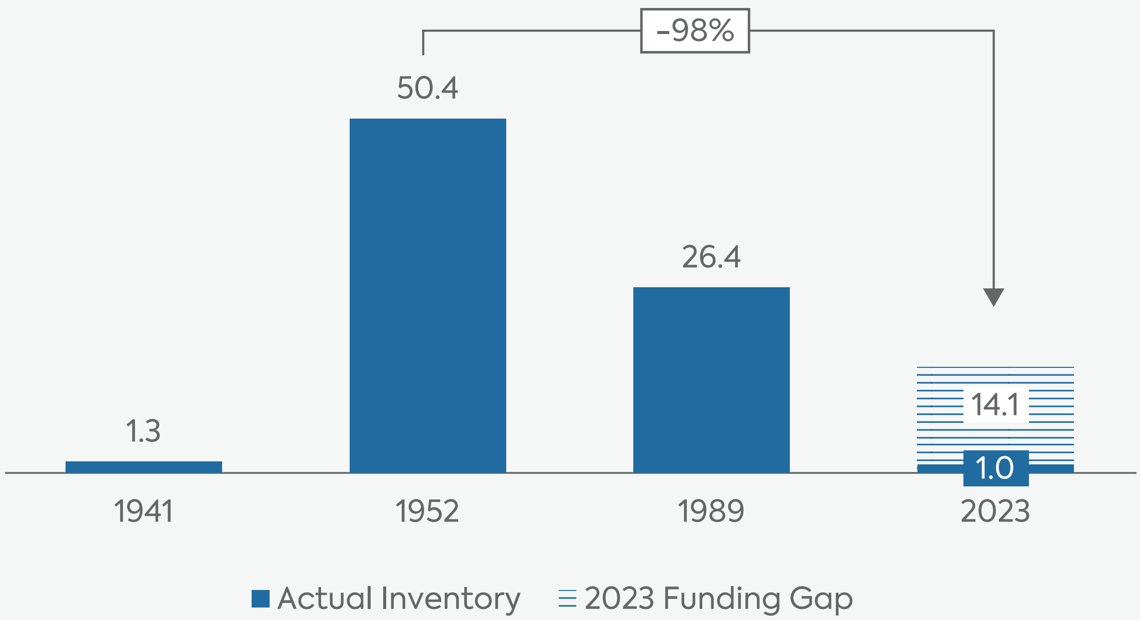
Case Study #1: US NDS (cont'd)

Figure 1: Value of US NDS inventory (billions, in 2024 dollars)



Sources: National Research Council, Managing Materials for a Twenty-First Century Military (Washington, DC: National Academies Press, 2008), https://nap.nationalacademies.org/read/12028/chapter/4#28; Cameron M. Keys, "Emergency Access to Strategic and Critical Materials: The National Defense Stockpile," November 14, 2023, https://sgp.fas.org/crs/natsec/R47833.pdf.

Several factors explain the decline of the NDS. The US Congress appropriated an annual average of over $3 billion (2024 dollars) from 1939 to 1969, which has steadily dropped since then to a combined $0.2 billion for fiscal years 2022 and 2023.[17] From fiscal year 2003 to fiscal year 2018, Congress diverted almost 90 percent of NDS proceeds to other defense and nondefense programs.[18] Finally, ongoing capital and operational expenditures have slowly drained funds over time.

Projections indicate that the NDS is likely to be unable to sustain its operating expenses without increased appropriations.[19] According to an FY2023 stockpile assessment, the US faces an estimated shortfall of $15.5 billion (2024 dollars) across 88 materials.[20] Most of this shortfall is in essential civilian demand ($12.8 billion), with a lesser shortfall ($2.6 billion) in direct military requirements. The NDS held $1.4 billion in assets and $1.0 billion in inventory as of FY2023, implying a funding gap of $14.1 billion and an inventory gap of $14.5 billion (all in 2024 dollars).[21] As of FY2023, the NDS only covered 6 percent of total net shortfalls in the base case national emergency scenario.[22]

The state of the NDS illustrates the reluctance of policymakers to fund and implement even a popular national security stockpile. An economic stockpile would require even more funding to implement because of the large scale of mineral requirements. Given the lack of appropriations so far, those seeking an economic stockpile would probably have to favor, for now, a hybrid approach to material stockpiling that blends national security and economic considerations.

Supporting Objectives

The choice between defense and economic stockpiles is not the only factor in the design of stockpiling systems. Stockpiles can also serve several supporting objectives. These objectives include:

- *Expanding mining and processing capacity*: If authorized, stockpiles can offer domestic mineral producers offtake agreements. These agreements can help new operations raise capital and weather volatile price environments. Offtake agreements could also be applied to allied foreign suppliers. Such stockpiles could help reduce dependency on a single supplier or region by diversifying global production. This is particularly important given the geographic concentration of mineral processing in China.
- *Increasing domestic downstream capacity:* A stockpile can increase supply chain resilience by selling low-cost materials to domestic manufacturers during market turbulence. This derisking could positively impact companies' long-term investment decisions.
- *Supporting socially and environmentally responsible mining and processing:* Stockpiles can prioritize purchasing materials that have been produced in the most socially and environmentally responsible way and exclude the worst ESG offenders, such as cobalt coming from artisanal mines with child labor. Such purchasing would increase demand for supply that would otherwise struggle to compete with cheaper minerals produced with worse environmental and labor standards. Such demand may be important, since private markets currently do not seem intent on paying premiums for more sustainably produced minerals.[23]
- *Providing geopolitical leverage:* Robust stockpiles can dissuade other countries from weaponizing critical minerals to advance foreign policy objectives. For example, stockpiles of

antimony, gallium, germanium, and graphite would allow the US to pursue its trade agenda with China without fearing Chinese countermeasures of bans on these mineral exports to the US. Even as early as 1947, the NDS was seen as a potentially strong tool to deter would-be aggressors.[24] This was similarly a key rationale for the establishment of the US Strategic Petroleum Reserve in 1975.

Most of the supporting objectives listed above can be pursued when governments focus on economic rather than national defense stockpiles. However, while economic stockpiles have many potential benefits, they are also exposed to substantial risks. One major area of risk is fiscal. Governments must stockpile large quantities of material to meaningfully pursue supporting objectives, and that would require sizable funds to purchase, store, and manage stockpiles.[25] (The authors explore this further in "Choice 5: Trade-offs between Costs and Stockpile Depth.")

Choice 2: Critical Minerals to Stockpile

Those establishing a critical mineral stockpile must determine exactly which minerals to acquire and in what quantities (for the authors' assumption on quantities, please see below). Regardless of its structure, a stockpile will always have a fiscal ceiling on expenditure that forces policymakers to assess how to optimally spread annual budgets across minerals and how to prioritize acquisitions.

Policymakers must therefore assess the "criticality" of each mineral, the quantity of minerals required to provide a buffer against shocks, and the most efficient way to use limited funds to reduce national vulnerabilities. The criticality of each mineral is not a simple assessment. Criticality first and foremost depends on the primary objective of a stockpile. For example, certain minerals like beryllium may prove important in a defense-focused stockpile, while an energy-focused stockpile may place a greater need on a material like lithium.

The US currently maintains two separate lists to measure a mineral's "criticality." The Energy Act of 2020 provides the Department of Energy (DOE) and Department of the Interior with the joint responsibility of determining the list of critical (energy) materials but provides the Department of the Interior—acting through the director of the US Geological Survey (USGS)—with the sole authority to determine the US list of critical minerals.[26] The two lists are based on different methodologies, include some different minerals, and are tied to different federal programs. (Furthermore, those in the Department of Defense making acquisitions for the NDS consider minerals on both lists but are ultimately guided by yet another set of criteria, described below. In fact, certain minerals in the NDS do not qualify as a US critical mineral or a critical energy material.)

The USGS critical minerals list currently identifies 50 critical minerals.[27] The Energy Act of 2020 defines minerals as critical if they are "essential to the economic or national security of the United

States; have a supply chain that is vulnerable to disruption; and serve an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economic or national security of the US."[28] The USGS evaluates mineral criticality based on the likelihood of a foreign supply disruption, the level of import reliance, and the vulnerability of the US manufacturing sector to a supply shortage.[29] The agency integrates additional dynamics into its determination, such as whether a mineral supply chain has a single point of failure.

The USGS list only considers the current level of criticality; it was last updated in 2022 and is reviewed every three years. Mandated reviews ensure that critical mineral designations are dynamic rather than static. For example, the updated list in 2022 added nickel and zirconium while removing helium, potash, rhenium, and strontium. Nevertheless, Congress is actively considering changes to the definition, methodology, and list of critical minerals in the United States.[30]

The DOE Critical Materials List[31] solely focuses on materials that are required for energy technologies and is therefore smaller than the USGS list. It includes "the electric eighteen": 16 minerals and two materials (electrical steel and silicon carbide).[32] The list includes two minerals (copper and silicon) that are not on the USGS list.

The methodology for determining the DOE Critical Materials List consists of two main variables: importance to energy and supply risk.[33] A material's importance to energy is based on the percent of its demand that comes from energy applications and its substitutability. Supply risk is assessed based on future global supply-demand balances, growth in demand from competing nonenergy technologies, perceived risk of existing global suppliers, level of codependence on other material markets, and diversity of the global supply landscape. While the USGS list is US-centric, the DOE list evaluates global risks for the development and deployment of clean energy technologies and is explicitly forward-looking, with short- and medium-term scenarios. DOE has stated that it plans to update its assessment by around 2026, three years from the release of the list.[34]

The US Department of Defense, as noted above, employs a separate process for evaluating which minerals are included in the NDS. The NDS list of *strategic and critical materials* includes those to meet military, industrial, and essential civilian needs during national emergencies that are not sufficiently found or produced in the US.[35]

The Defense Logistics Agency selects materials that are expected to be in "material shortfall" in a base case national emergency scenario.[36] The base case scenario consists of a military conflict and an attack on US soil, with one year of active combat and three years of post-conflict recovery. The Defense Logistics Agency monitored 283 materials for recent stockpile assessments and incorporated 148 of those materials into formal planning models. As of 2021, 53 strategic and critical materials were determined to be in shortfall in an armed conflict scenario involving China.[37]

Most materials in the NDS inventory are part of the USGS critical minerals list, but others are not on that list or the DOE Critical Materials List.[38] Additionally, while the USGS and DOE lists include broad categories of materials, the Defense Logistics Agency must determine the exact form of material to stockpile. For example, the NDS currently holds three forms of germanium: germanium metal, germanium wafers, and germanium scrap. This highlights an important responsibility stockpiling managers have to determine which stage of minerals to stockpile.

Choice 3: Stage of Critical Minerals to Stockpile

Critical minerals exist along a continuum, ranging from raw ores extracted from mines to fully processed and refined chemical or metal compounds. Raw ores undergo several stages of processing (often including mechanical, hydrometallurgical, pyrometallurgical [or smelting], and electro-refining operations) that involve greater technological complexity to achieve higher levels of purity—with clean energy technologies often requiring the highest purity material. In some cases, purified minerals are further processed into chemical compounds, enabling specific electrochemical reactions crucial for applications like batteries. In other words, a large variety of different raw, intermediate, and refined forms of materials can be stockpiled.

Table 1 summarizes key technical challenges in stockpiling that need to be considered when devising a stockpiling strategy. An inverse relationship exists between ease of stockpiling and relevance for downstream industries. In other words, without processing infrastructure in the US or allied countries, stockpiling minerals that do not have ultrahigh purity levels needed for the digital economy, clean energy, and national defense applications is moot.

The form of material to stockpile should be guided by the objective of the stockpile, the context of the market, and the makeup of the rest of the supply chain. It may initially seem logical to stockpile raw ores since they can be converted into different types of end products. But stockpiling ores is problematic since China dominates global processing capacity for many minerals.[39]

Given that the US and its allies lack industrial capacity to process most critical minerals, the most practical and prudent choice in the short-to-medium term is to stockpile a processed material that can be used directly by US companies in times of a shortage. In the long term, it is imperative for the US to build domestic and support allied processing capacity to mitigate supply risks.

Table 1: Technical challenges of stockpiling a sample of critical minerals

Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Lithium					
Lithium brine	Raw	<1%	Low	Low	• Massive storage needs due to low purity level • Can be stored in bulk tanks, underground salt domes, ponds • Bespoke processing needed to deal with impurity challenges that are unique to each source
Lithium brine (postevapo-ra-tion)	Raw	6%–10%	Low	Low	• Massive storage needs due to low purity level • Can be stored in bulk tanks • Requires the buildout of processing facilities designed around the source of brine
Lithium chloride	Raw	30%–60%	Low	High	• Can be stored in supersacks in warehouses • Very hygroscopic (degrades with exposure to even small amounts of water)
Lithium carbonate	Processed	99%–99.5%	Low	Medium	• Highly concentrated, requiring relatively little space • Can be stored in supersacks in warehouses • Very stable shelf life, though after 18–24 months, the material can start to lose some of its needed specifications
Spodumene ore	Raw	<3%	Low	Low	• Massive storage needs due to low purity level • Can be stored outside on the ground • Requires processing to achieve concentrated status
Spodumene concentrate	Raw	5%–6%	Low	Low	• Stable shelf life and reasonable cost of storage • Can be stored in a covered building on the ground • Physical parameters require qualification by buyers
Lithium sulfate	Processed	85%–99%	Low	Medium	• Stable shelf life and reasonable cost of storage • Can be stored in supersacks in warehouses

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Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Lithium (cont'd)					
Lithium hydroxide	Processed	>99.5%	High	High	• Hygroscopic • Stable up to one year with appropriate storage conditions due to issues with caking • For lithium hydroxide monohydrate (battery grade suitable for use by cathode active material producer) there are limited buyers and sellers and they must be matched based on quality and technical parameters
Lepidolite ore	Raw	<2%	Low	Low	• Massive storage needs due to low purity level • Can be stored in a covered building on the ground • High waste generation per lithium carbonate equivalent (LCE) unit
High-purity lithium chloride	Processed	99.5%–99.9%	High	High	• Can be stored in supersacks in warehouses • Very hygroscopic (degrades with exposure to even small amounts of water)
Lithium metal	Processed	>99.9%	High	High	• High in LCE content • High cost of handling • Can be stored in bulk drums • Potential degradation concerns without proper precautions (e.g., stored in oil or under Argon blanket)
Nickel					
Nickel sulfide ore	Raw	<3%	Low	Low	• Massive storage needs due to low purity level
Nickel concentrate	Raw	10–20%	Low	Low	• Easy to store but still bulky

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Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Nickel (cont'd)					
Nickel matte	Processed	30%–75%	Medium	Medium	• Nickel matte can react with air or moisture over time, potentially leading to sulfide oxidation. This requires storage in dry, controlled environments to prevent degradation • Oxidation of sulfides can lead to material loss and create sulfuric acid that can over time corrode certain storage container materials
Converted nickel matte	Processed	75%–90%	Medium	Medium	• See nickel matte, but higher nickel content means lower sulfur content and as a result a bit less reactive • Still requires protection from moisture and air to avoid sulfide oxidation
Nickel solution	Processed	95%–99%	Medium-High	Medium-High	• Requires storage in corrosion-resistant tanks. Even then, shelf life is generally relatively short (<2 years at best) • Solutions can degrade via precipitation or contamination if they aren't stored under correct pH and temperature control
Purified nickel sulfate	Processed	>99.5%	Medium	Low-Medium	• Relatively stable but can absorb moisture, which reduces quality over time • Possible to hold under controlled environment without any exposure to moisture or air
Battery grade Class 1 nickel sulfate	Processed	>99.9%	Medium-High	Low-Medium	• Must be stored under very strict conditions to maintain its quality. Any type of contamination from air or moisture would lower its battery-grade status • Liquid nickel sulfate lasts about six months • Crystallized nickel sulfate lasts up to two years • Some companies invest in electrodeposition, to turn sulfate to metal (electrolytic nickel) for longer storage. In this case, it can be stored for years because after the surface oxide film is formed, it will no longer oxidize)

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Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Manganese					
Manganese ore (pyrolusite)	Raw	>35%	Low	Low	• Manganese ore could be stored for years; if stored for too long, the grade may drop slightly (at least after two years), especially for powder ore
High-purity manganese sulfate monohydrate (HPMSM)	Processed	>99%	Medium	Medium	• Shelf life is usually one year • It will clump around one year—the chemical will not change, but it will be more difficult for producers to use
High-purity electrolytic manganese metal (HPEMM)	Processed	>99%	Medium	Low	• Can be stored for years because after the surface oxide film is formed, it will no longer oxidize
Cobalt					
Cobalt ore (sediment hosted deposits)	Raw	0.17%–0.25%	Low	Low	• Purity levels are too low for this type of storage to be viable
High-purity "chemical grade" cobalt sulfate	Processed	>99.9%	High	Medium	• Shelf life is approximately three years if stored correctly, although it could be extended (i.e., under closed conditions at room temperature) • If it is the anhydrous form of this substance, it would be hygroscopic and other storage conditions would apply (see cobalt (II) hydroxide below)

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Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Cobalt (cont;d)					
Battery grade cobalt (II) hydroxide	Processed	>99.8%	High	Medium	• Shelf life is approximately two years if stored correctly, although it could be extended (i.e., tightly closed container in a dry, cool, well-ventilated place) • Certain types of cobalt (II) hydroxide can be considered severely hazardous substances, so additional conditions could apply (i.e., limit the amount that can be held on site) • There is an oxidation risk for several cobalt substances, which is why they are sometimes stored under a nitrogen atmosphere
Graphite					
Natural flake graphite ore	Raw	2%–30%	Low	Low	• Massive storage needs due to low purity level • Relatively uncomplicated handling and storage requirements
Flake concentrate	Processed	80%–97%	High	Medium	• The size of the individual particles, which are typical below 1 millimeter for flake and below 50 micrometers for CSPG (see below), should be considered • Storage induced particle-particle friction can lead to material deformation, and in the worst case carbon dust ignition • In general, these materials are best kept under dry, dark, and frost-free conditions • Due to high chemical stability, the only major chemical degradation comes from either hot or very cold gasses, which could occur during a fire in the storage facility

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Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Graphite (cont'd)					
Coated spherical purifie graphite (CSPG)	Processed	99.90%	High	Medium	• There is oxidation risk: exposure to oxygen and humidity can lead to surface oxidation. CSPG needs to be stored in a dry and controlled environment • In battery applications, CSPG is very sensitive due to its required purity levels to perform optimally • CSPG is generally stable, but improper storage will degrade its coating or surface quality pH and temperature control
Phosphate					
Phosphate rock	Raw	4%–20%	Low	Low	• Purity levels are too low for this type of storage to be viable
Beneficiated phosphate rock	Raw	>28%	Low	Low	• Beneficiated igneous anorthosite feedstock can be stored ad infinitum and converted quickly to large amounts of pure phosphoric acid (PPA) at any time
Pure phosphoric acid (PPA)	Processed	85%–100%	High	Medium	• Needs to be stored in liquid containers and requires heated storage, as the freezing point is generally 21.1°C or 70°F • Can be stored for one to five years, though discoloration can result after 6–12 months (this is an issue for the food industry and not for battery usage) • Generally, PPA is not stored more than 6–12 months during industry downturns, given the large amount of expenditure involved in producing it
Gallium					
Gallium arsenide	Processed	>99.9%	High	High	• High toxicity risk due to arsenic • Requires controlled atmosphere storage as it can release toxic compounds • Any surface degradation can affect semiconductor quality

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Product	Processing stage	Average purity level	Storage complexity	Degrading potential	Technical considerations
Gallium (cont'd)					
Gallium metal	Processed	>99%	Medium	Low	• Shelf life is years or even decades • Can be stored in small containers due to its low melting point just above room temperature (29.7°C) • Is unreactive in air at room temperature and may oxidize very slowly, especially in presence of moisture/humidity, to form a protective layer
Germanium					
High-purity germanium crystal	Processed	>99.9%	High	Low	• Germanium crystal is a high-purity metal grown as a single crystal (single crystal is necessary for infrared optics [IR] and PV applications, so it is also a value-added product and expensive to make) • The crystal form is stable but also fragile, as germanium metal will shatter if dropped/hit. The crystal is useless in IR/PV applications if shattered.
Germanium metal	Processed	>99.9%	Medium	Low	• Can be stored as a metal ingot indefinitely and does not oxidize at room temperature • Over a long period of time, there may be a small amount of oxidation on the surface of the ingot, especially if moisture/humidity are present, but this is minimal and the germanium oxide will be on the surface, stay with the ingot, and be recoverable • The metal is fragile and will shatter if dropped or hit with relatively small force
Germanium oxide	Processed	>99.9%	Medium	Low	• Can be easily stored long term in containers • Not reactive in air at room temperatures, making it relatively easier to handle

Note: Degradation level is divided into low (can be stored for more than five years), medium (can be stored for one to five years), and high (can be stored for less than one year).
Source: Author compilation based on industry consultations and: Canadian Manganese 2024[40]; Canadian Mining Journal 2020[41]; British Geological Survey 2009[42]; Frenzel, Ketris, and Gutzmer 2014[43]; USGS 2021[44]; International Agency for Research on Cancer 2006[45]; Geomega Resource 2024[46]; Graphano Energy 2024[47]; Jara, Betemariam, Woldetinsae, and Kim 2019[48]; Next Source Materials 2024[49]; Ritoe, Patrahau, and Rademaker 2022[50]; Saltworks 2021[51]; Schulte and Foley 2014[52]; Syrah Resources 2024[53]; Umicore 2024[54]; and Zapata and Roy 2004.[55]

In addition to the objective of the stockpile, industrial capacity, and available funds, deciding which form of material to stockpile depends on several technical assessments:

1. *Shelf life of raw versus processed materials:* Mineral ores often have a longer shelf life (i.e., the length of time that the material remains fit for use) compared to their processed counterparts. This makes long-term storage of processed materials more complex and costly.

2. *Infrastructure:* Stockpiling minerals requires specialized physical infrastructure and technology for inventory management. Physical infrastructure differs significantly for storing and transporting ores versus processed materials. While raw ores are typically more robust and less sensitive to environmental conditions, allowing for more straightforward storage, they have low purity levels, requiring more volume and weight be stored. Sulfide ores, for example, typically contain less than 3 percent copper and nickel. Once minerals are processed, especially for use in clean energy technologies, they can become more chemically reactive or sensitive to environmental conditions like humidity, temperature, and exposure to air, degrading over time. Processed materials thus require specialized storage facilities that control temperature, humidity, and contamination. Additionally, the logistics of transporting processed materials are more stringent due to their sensitivity and higher value.

3. *Human capital:* Managing the stockpiling of processed materials requires trained personnel who understand the specific needs of these materials. This includes experts in material science who can advise on optimal storage conditions, as well as logistics professionals skilled in handling and transporting sensitive materials. The US currently lacks this specialized workforce. (Furthermore, it is essential to have security personnel trained to protect high-value stocks and IT specialists to manage inventory systems.) In contrast, stockpiling ore is often less technically challenging and may require less specialized employees.

These challenges are not hypothetical. In 2021, the US Defense Logistics Agency released part of its tin stockpile in response to concerns of consumers who were dealing with high premiums and uncertain deliveries from Southeast Asia. However, the 400 tons of tin sold from the defense stockpile had degraded significantly due to prolonged storage and needed re-smelting and upgrading before it could be used.[56] Effective management, not only in terms of technical storage and transport but also inventory management, is required to successfully stockpile critical minerals.

Choice 4: Management System

The management of a stockpiling system for critical minerals can take several forms, each with its own advantages and operational frameworks. The most discussed option is publicly owned stocks, which are directly controlled and financed by the government. These stocks are funded by the federal budget, with capital and operational expenses covered by taxpayer money. The advantage of such stockpiles is that they offer a high level of control and reliability without relying on private sector cooperation. This is how the Strategic Petroleum Reserve (SPR) was designed.

A second option is agency stocks, which are managed by a semi-independent organization or agency. These agencies can be government-sponsored or created through public-private partnerships. Agency stocks can be funded through a mix of government appropriations, industry fees, or loans. A specialized agency manages the stockpile, with oversight from the government, and might hold the stocks directly or supervise private entities that maintain the stocks. The advantage of this model is that it offers more flexibility in management, funding, and operation. The agency's specialized focus and expertise can also lead to more efficient stock management.

A third option is mandatory industry stocks, in which the government requires private companies to hold a certain level of material stockpiles. Affected companies would be those that import, refine, or otherwise use critical minerals in their operations. The costs of maintaining stocks are borne by the private sector, with companies likely passing expenses on to consumers. While private companies manage their own stockpiles, they must adhere to regulations and oversight by the government. This approach reduces the financial burden on the government and leverages private sector efficiency and infrastructure for stock management. Mandatory industry stocks are similar to the oil stockholding requirements in some International Energy Agency (IEA) member countries, where refiners and importers must hold a minimum level of oil stocks.[57]

Finally, a mixed approach combines elements of public, agency, and mandatory industry stocks, trying to integrate the benefits of all three systems. This model can be financed through a combination of public funds, industry fees, and possibly other financial instruments like loans or bonds. Some European countries use mixed approaches for their oil stockpiles, combining public strategic reserves with mandatory industry stocks.[58]

When deciding on the management system, several factors should be considered, including the need for public control and the cost of the system on government, private actors, and consumers. Effective communication and coordination among stakeholders—government, semi-independent agencies, and industry—are critical, with regular monitoring and reporting ensuring that stockpiles meet strategic goals and remain ready for deployment. Importantly, the system should be adaptable to changing market conditions, technological advancements, and evolving strategic needs, including the ability to adjust stockpile compositions and management practices.

Case Study #2: IEA Strategic Oil Stockpiles and Mineral Stockpile Discussions

The IEA was founded in 1974 in response to the 1973 global oil crisis. At the center of its mandate was the Emergency Response Program, which included a legally binding requirement for member countries to maintain strategic petroleum stockpiles equivalent to at least 90 days of net imports.[59]

IEA members can take a variety of approaches to meet stockpiling obligations, including the types discussed in this paper: government-owned reserves, agency-managed inventories, and industry-obligated stocks. The most prominent example is the US SPR, but other countries, such as Japan and Germany, also maintain significant reserves.[60] The Emergency Response Program provides adaptability of the IEA framework to different national contexts so member countries can tailor their stockpiling strategies to domestic energy needs and market structures.[61]

Releases from the IEA stockpile have occurred multiple times since its inception, including during the 1991 Gulf War, the aftermath of Hurricane Katrina in 2005, and the coordinated response to the Libyan civil war in 2011.[62] These releases have provided liquidity to global oil markets that helped prevent severe price hikes and ensured continuity of supply to downstream industries.

In recent years, the IEA has expanded its scope beyond petroleum. As the energy transition accelerates, the IEA has recognized the strategic importance of critical minerals for clean energy technologies. Geopolitical and market risks associated with the concentration of critical mineral production has become a core concern of IEA member countries, which are overwhelmingly net importers of most critical minerals. While the IEA does not mandate mineral stockpiles, it is actively discussing mineral stockpiling with its member states.

IEA engagement with critical minerals is currently facilitated through two closely linked structures. The first is the Critical Minerals Security Program (CMSP), established in 2022. This program connects interested members to discuss and study critical minerals supply security. The CMSP focuses on mineral-specific risk assessment and dialogue, security measures including stockpiling, and country reviews. The program follows a more voluntary approach than the Emergency Response Program. The CMSP will follow a phased approach where an initial review and learning phase is to be followed by an operational phase where "mechanisms" (which aren't yet specified by the IEA) are implemented by participating members.

The second structure is the IEA Critical Minerals Working Party, also established in 2022. The Working Party sits within the IEA's Secretariat to facilitate research and analysis, provide a platform for dialogue, and help coordinate the actions of the CMSP.

Choice 5: Trade-offs between Costs and Stockpile Depth

Cost is a key variable in designing any stockpile. The cost to build a critical mineral stockpile will depend on three decisions: how much to stockpile (depth), what to stockpile, and which form of material to stockpile. Market prices and operational expenses also contribute to stockpiling costs.

Influence of Quantity on Stockpile Cost

As discussed, policymakers must decide whether a critical mineral stockpile will be strictly for defense or will serve a wider economic purpose, or both. Regardless, quantity will be a key determinant of cost.

Illustrative stockpiling costs for two sample design options follow.

1. *Defense-oriented stockpile for three months of US consumption:* This level of stockpiling is modeled off the IEA's requirements for oil stockpiles, which mandate that member countries hold stocks equal to at least 90 days of net imports. Such a stockpile would not offer perfect insulation from shocks but would enhance resilience, particularly if multiple countries adhere to the stockpiling guidelines and coordinate stockpile releases.

2. *Economic stockpile to act as a swing producer (i.e., it would time purchases and releases to stabilize mineral prices):* The authors assume, based on historical analysis of volatility in oil and mineral markets, that an economic stockpile will need volume equivalent to at least 10 percent of global supply to materially affect price.[63] However, the effectiveness of swing capacity ultimately depends on market dynamics and the scale of supply disruptions. The assumption of 10 percent is likely a minimum level of required capacity; for certain minerals, more capacity

could be needed to react to larger disruption potential—particularly in more concentrated markets with less elastic supply.

For the evaluated subset of minerals detailed in Table 2, the authors estimate that acquisitions for the defense-oriented stockpile would cost $6.6 billion, compared to $41.0 billion for the economic stockpile of the same subset of minerals. These numbers are based on average prices over the last five years and 2023 volumes of US consumption and global production.

Table 2: Modeled defense and commercial stockpiles, based on average prices, consumption, and global production from 2023

Defense

Mineral	Type	Quantity (three-month)	Price	Total acquisition cost	Refined?
Lithium	LCE	3,992	$31,911	$127,398,287	Yes
Cobalt	cathode (US spot)	2,075	$52,127	$108,164,176	Yes
Natural Graphite	Flake	19,000	$1,467	$27,868,440	No
Nickel	LME	47,500	$21,072	$1,000,906,605	Yes
Manganese	44%	172,500	$602	$103,900,545	No
Copper	COMEX, high grade	450,000	$8,797	$3,958,468,624	Yes
Silicon	Metal	123,750	$4,775	$590,924,763	Yes
Gallium	High purity, refined	5	$644,862	$3,063,095	Yes
Germanium	Metal	8	$1,397,392	$10,480,440	Yes
Phosphate	Fob mine (rock)	6,000,000	$96	$573,709,200	No
Rare earth Elements	Rare earth oxides	2,200	$23,753	$52,255,765	Yes
Total				**$6,557,139,939**	

Economic

Mineral	Type	Quantity (10% global market)	Price	Total acquisition cost	Refined?
Lithium	LCE	95,814	$31,911	$3,057,558,880	Yes
Cobalt	cathode (US spot)	23,000	$52,127	$1,198,928,221	Yes

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Economic (cont'd)

Mineral	Type	Quantity (three-month)	Price	Total acquisition cost	Refined?
Natural Graphite	Flake	160,000	$1,467	$234,681,600	No
Nickel	LME	360,000	$21,072	$7,585,818,480	Yes
Manganese	44%	2,000,000	$602	$1,204,644,000	No
Copper	COMEX, high grade	2,700,000	$8,797	$23,750,811,743	Yes
Silicon	Metal	380,000	$4,775	$1,814,556,848	Yes
Gallium	High purity, refined	61	$644,862	$39,336,582	Yes
Germanium	Metal	14	$1,397,392	$19,563,488	Yes
Phosphate	Fob mine (rock)	22,000,000	$96	$2,103,600,400	No
Rare earth Elements	Rare earth ox-ides	35,000	$23,753	$831,341,709	Yes
Total				**$41,009,500,242**	

Note: Estimates of acquisition costs are the total quantity required in the given stockpile multiplied by the average annual benchmark price of the listed product over the last five years. The same methodology is used to calculate the market sizes referred to throughout the report, with the exception that the price is the 2023 average benchmark price rather than the five-year average. While the resulting figures are not an exact market size, they provide a useful and consistent general estimate.

Source: Author calculations using US Geological Survey, "Mineral Commodity Summaries 2024," 2024, https://pubs.usgs.gov/periodicals/mcs2024/mcs2024.pdf.

This analysis does not focus on the total cost of a stockpile but rather the difference between the acquisition cost of building a defense stockpile and an economic stockpile. It finds that an economic stockpile holding 10 percent of swing capacity would likely cost a minimum of six times that of a defense stockpile. Estimates of stockpiling operations in the European Union show that storage costs (including land, transport, and building) are less than 1 percent of the total cost of stockpiling;[64] acquisition costs are the main driver of a stockpile's total expenditure. Given the NDS, with its defense mandate and broad political support, is severely underfunded, it will likely be politically complicated to gain the funding for an economic stockpile that could cost six times more.

Influence of Mineral Selection on Stockpile Cost

Domestic consumption and global market size vary substantially by critical mineral. For example, the US imported $45 million worth of germanium in 2023, and the size of the global germanium market was likely around $200 million that year.[65] In comparison, the US imported $9.9 billion of copper in 2023, and the global copper market was slightly over $230 billion.[66] The costs of building stockpiles of germanium and copper are on completely different scales. The authors estimate an economic stockpile for copper would cost more than $23 billion to build, but a commensurate approach aimed to stabilize the germanium market would only cost around $20 *million*.

In addition to cost, the decision of which minerals to stockpile depends on the purpose of the stockpile and mineral criticality. Deciding to stockpile lithium, for instance, depends on whether a stockpile only covers defense or also includes energy security. As to criticality, bulk commodities and base metals like copper face the prospect of global shortages but are part of mature markets that cannot be easily manipulated by any single actor. Meanwhile, niche commodities like gallium exist in heavily distorted markets and face a large threat of disruption. Criticality assessments, using the existing USGS methodology, can help guide the volume of stockpiling for each mineral.[67]

To consider costs, policymakers may find it useful to adopt an industry categorization framework that differentiates between bulk metals (e.g., iron ore), base metals (e.g., copper), battery materials (e.g., lithium and cobalt), and niche metals (e.g., gallium).

The markets for bulk and base metals generally exceed $50 billion, and often $100 billion. Many of these minerals may be impractical to stockpile. Fortunately, most bulk and base metals also have a lower "criticality" rating due to the maturity and diversification of the markets. Some exceptions do exist, like high-purity iron ore, which is a rarer form of iron ore important for decarbonization and therefore designated as a critical mineral in certain countries such as Canada.

In contrast, battery materials like lithium, graphite, and cobalt are smaller, more concentrated, and have more volatile markets. These commodities all have a high criticality rating. Nickel and manganese are also important in batteries and could be included in this category, despite often being categorized as base metals. On the high end of stockpiling costs, acquiring swing capacity for Class 1 nickel could be around $8 billion.[68] On the low end, flake graphite could cost as little as $200 million.[69]

Stockpiling costs for battery materials could rise if foreign entities of concern (China, in particular), are excluded from acquisitions. Since many critical minerals are produced in China, acquiring material exclusively from outside China could likely come at a higher price, as ex–China market participants realize they can claim a premium for their material.

The cost of building stockpiles for battery materials could also grow significantly over time as demand for these materials expands. In the IEA's Announced Pledges Scenario (APS), global demand for lithium grows eightfold from 2023 to 2040.[70] Assuming prices are equivalent to the average price over the last five years, the cost of building a lithium stockpile would increase eightfold from 2023 to 2040. While an acquisition cost of around $3 billion for building an economic stockpile of lithium today may be manageable, maintaining such a stockpile could require a further $21.5 billion in acquisitions by 2040.[71]

Assuming historical prices and the APS growth trajectory, the cost of acquiring material for an economic stockpile of lithium, nickel, cobalt, and graphite could more than triple, increasing by over $30 billion, between 2023 and 2040 (in real terms).[72] Policymakers must consider demand growth when making stockpiling decisions; otherwise, costs will not be planned for sufficiently.

The last group of minerals are often labeled niche metals, which include rare earths, gallium, and germanium. Most niche metals have heavily distorted markets prone to market failures due to concentration, subsidization, opacity, inelastic supply/demand, and externalities. Niche metals are strong candidates for policy intervention. The costs of building economic stockpiles of these materials are also lower. The authors assess that the cost of acquiring 10 percent swing capacity in gallium and germanium combined would be under $100 million.[73] Building a similar share in the rare earths market would cost under $1 billion, potentially expanding to slightly under $2 billion by 2040.[74]

Acquiring a 10 percent share of global supply of any single commodity could cost more than initially assumed due to the price response from markets. Commodity markets are often finely balanced, with even a 2–3 percent surplus or deficit often having a significant influence on price. It would therefore likely be prudent to build economic stockpiles over the course of five or more years. Even then, stockpile purchases could raise prices and lead to speculation, which would further increase acquisition costs.

Influence of Processing Stage on Stockpile Cost

The decision around processing stage will influence acquisition costs.

Manganese, for example, can be used in multiple forms. Most manganese is processed into ferroalloys used for steel. Increasingly, manganese is also processed into high-purity manganese sulfate for use in lithium-ion batteries. On a contained metal basis, manganese ore typically ranges from 15–30 percent of the cost of refined forms of manganese, such as ferromanganese or manganese sulfate.[75]

Manganese ore would be substantially cheaper to acquire and easier to manage than manganese sulfate. Stockpiling manganese ore would also offer more options for processing flexibility and could help provide assured feedstock for US processing operations. But the US does not currently have any capacity to process manganese ore into manganese sulfate. If a stockpile was forced to acquire refined manganese rather than manganese ore, the acquisition cost of an economic stockpile would rise from $1.2 billion to over $3 billion.[76]

A similar dynamic takes place with nickel. In Table 2 above, an economic stockpile of Class 1 nickel accepted by the London Metal Exchange costs just under $8 billion. Alternatively, the price of building a similar stockpile of contained nickel in the form of ore could reduce the cost of a stockpile by about two-thirds.[77] Yet, like manganese, the US does not currently have capacity to refine nickel ore into key products like nickel sulfate, which is used in lithium-ion batteries.

The more processing a mineral undergoes, the higher the cost of acquisition. In certain cases, acquiring processed minerals will also raise the cost and difficulty of stockpile management. The efficacy of stockpiling ore, however, will ultimately depend on the availability of downstream processing capacity in the US or allied countries.

Influence of Purchasing Mechanisms on Stockpile Costs

Policymakers can grant stockpile managers the authority to use different purchasing mechanisms, which in turn determine the cost of building a stockpile and its influence on the market.

The NDS purchases most of its material on spot markets at the prevailing market-based price. Purchases on the spot market are a transparent and simple way to acquire material. However, there is an ongoing debate over whether the United States could use more creative purchasing authorities to incentivize domestic production of critical minerals.[78] If properly implemented, these mechanisms could lower supply risk by increasing domestic capacity. They could also potentially lower acquisition costs.

Forward contracts are one such instrument and are already used by the US SPR. A forward contract is a private agreement to buy and sell an asset at a specified date in the future. Forward contracts provide price certainty to both the buyer and seller. Use of these contracts can help hedge risk for a stockpile by balancing its purchases between prenegotiated prices of forward contracts and live prices of the spot market.

Forward contracts can also incentivize more domestic supply by stabilizing the revenue of existing producers and providing certainty to new projects to enhance their bankability. Domestic critical mineral projects currently struggle to raise finance due to lenders' concerns over demand and price.[79] A forward contract can derisk both variables and help new projects enter production.

Advance market commitments (AMCs) are another potential tool for a stockpile. AMCs are a commitment to purchase or subsidize a product if it is produced. AMCs have been widely used to support production in different industries, including for new vaccine development.[80] These commitments are useful to jump-start markets with large social benefits.

AMCs could be used by a critical material stockpile for a similar purpose. The cost of this approach would depend on the scale of production, price set by the AMC, and market price. For example, a US stockpile could pledge to purchase domestically produced cobalt metal at a price of $45,000 per ton. If cobalt prices in the future are above $45,000 per ton, producers would sell into the market and not activate the AMC, implying no cost to the stockpile. However, if the market price is below $45,000 per ton, the stockpile would be obligated to purchase all domestically produced cobalt metal. An AMC can derisk projects and incentivize production, but costs can quickly spiral out of control without proper planning.

An alternative to an AMC is an advance purchase agreement (APA). An APA could be structured in a way that functions like an over-the-counter option for the seller: a producer would have the option, but not the obligation, to sell to a stockpile at a predetermined price. While an AMC is often broad and applies to the entire market, an APA could be specific and only apply to certain projects. These would function as a stockpile-to-company commitment rather than stockpile-to-market commitment. The more limited scope of APAs would help reduce stockpile costs and channel funding to strategic projects that would benefit most from price support. Yet this approach could be criticized for granting favoritism to specific companies.

Both an AMC and an APA are obligations to purchase material and will therefore likely appear as large liabilities on a stockpile's balance sheet. An alternative mechanism to lower initial expenditure is a contract for difference (CfD). This mechanism would establish a floor price and subsidize the difference between the floor and the market price when the market price is lower than the floor price. A CfD would not necessarily need to be run by a stockpile manager since it provides a subsidy rather than physically acquiring material. It could also be implemented quickly since it does not require building physical infrastructure.

Subsidies through a CfD would initially be cheaper than paying full price to acquire material through a mechanism like an APA. The downside is that a stockpile using a forward contract, AMC, or APA can later resell material to recuperate its costs, while a CfD is a pure subsidy and therefore an unrecoverable cost. A CfD could provide revenue for the government if the company agrees to pay the government the difference (in part or full) between the market price and floor price when the former is higher than the latter. However, such a structure would reduce the upside and attractiveness of the contract for the company producing the material.

Other Cost Influences

Maintaining a stockpile involves a variety of capital and operational expenses that can have a meaningful impact on cost, including capital expenses for purchasing land, warehouses, and equipment. Operational expenses include compensation for stockpile managers, contractors, and consultants, as well as other variable expenses such as logistics costs to transport material and technical costs for quality assurance.

The majority of a stockpile's costs need to be covered by annual appropriations; otherwise, a stockpile may be forced to adjust to a shrinking budget by reducing staff or selling material. Forced releases to cover operational expenses contributed to the decline of the NDS over the last several decades.[81]

Furthermore, a stockpile will often incur an insurance cost of inventory, particularly if the material is held by industry participants. Inventory insurance costs rise based on the quantity of material stockpiled and the time that material is held. They also depend on the material, which can come with specific risks such as flammability, toxicity, and radioactivity.

The costs of acquisition and maintenance will be considerably higher for an economic stockpile than for a defense stockpile. An economic stockpile will require more infrastructure, higher turnover of material, and more employees. An economic stockpile will also need to pay higher salaries for talent with experience in mineral forecasting, acquisitions, and trading.

Mineral prices will also obviously have a significant bearing on acquisition costs. Lithium prices, for example, rose nearly 600 percent from 2020 to 2022 before declining 50 percent from 2022 to 2023.[82]

Complications of a Buy-Low, Sell-High Approach

Proponents of an economic stockpile often argue that it could be self-sustaining by purchasing material when prices are low and releasing material when prices are high. It is certainly possible for an economic stockpile to adopt such an approach, which could result in reduced costs or an actual profit. But it is also important to understand the risks of such an approach.

Commodity cycles complicate the ability to buy low and sell high. Mineral prices, like those of all commodities, are inherently cyclical. These cycles often play out over various years and can even span over a decade. Longer cycles complicate the ability of a stockpile to time the market. For example, if a commodity is in a cycle of high prices, policymakers would have to choose between building a stockpile or waiting an unknown number of years before beginning to purchase material.

Timing commodity cycles is not easy. Market participants with significant expertise and resources—producers, consumers, traders, and financial institutions—actively take future positions on commodities, and none of them has any guarantee of a return. Likewise, there is no such guarantee for the US government. The potential for profit would require building substantial internal capabilities and would involve large risk.

Even if a stockpile is built during a low-price cycle, it may have to wait years before prices increase to sell the material. The copper bear market that came after strong prices in 2011 lasted until 2020. Holding physical material for nearly a decade results in large operational expenses. It also comes with an opportunity cost of capital. Maintaining $1 in a stockpile for nine years would result in a cumulative loss of $1.30, or 130 percent (not including operational expenses) assuming a 10 percent compound annual opportunity cost of capital. This opportunity cost, along with interest and insurance, is typically referred to as the "cost of carry" and explains why industry often avoids holding massive inventories or taking long-duration positions on physical trades.

The histories of the NDS and SPR further illustrate the complexity of insulating stockpile decisions from outside pressures, particularly when a stockpile explicitly has the objective of influencing prices. External pressure can come from various sources, including public officials in the legislative or executive branch placing pressure on stockpiles due to political rationale. Accusations of political interference will surround stockpile decisions, regardless of their validity, as has historically been the case with both the SPR and NDS.[83]

Domestic industry will also have a strong incentive to influence stockpile decisions, and an economic stockpile will result in geopolitical tensions if it influences global prices. Other countries may lobby for their own self-interest or heavily object to US efforts to control the global market. Any of these pressures could derail a stockpile's ability to operate impartially.

Nonetheless, an effectively implemented buy-low, sell-high approach could reduce total costs of a stockpile, even if it did not result in a profit. Were this approach to be adopted, policymakers could seek to manage political expectations that a stockpile will make money, thereby lowering political risk while allowing the potential for positive surprises.

Case Study #3: US SPR

The US SPR was established in 1975 after the Arab Oil Embargo of 1973.[84] Following US support for Israel during the 1973 Arab-Israeli War, the Organization of the Petroleum Exporting Countries banned oil exports to the US and began a series of cuts to oil production. The price of oil quadrupled from $2.90 a barrel before the embargo to $11.65 a barrel by January 1975.[85]

Since its establishment in 1975, the SPR has functioned as a last resort to protect against disruptions in the supply of oil. The SPR also has a mandate to allow US oil producers to store crude oil "when demand drops dramatically" to ease pressure on producers to stop production.[86]

The SPR's objectives and scope vary significantly from the NDS. The SPR is focused on energy security, not national security. It has an economic mandate to lower prices by releasing supply during disruptions or to support prices by purchasing oil during periods of weak demand. The SPR also differs from the NDS in that it focuses solely on oil rather than a basket of commodities. While the SPR is authorized to stockpile both refined products and crude oil, it has historically only stockpiled crude oil (sweet and sour varieties) since crude is less susceptible to degradation, allows for greater flexibility in end-use, and can feed a strong US refining industry.

Conversely, the US lacks sufficient processing capacity for many critical minerals, which implies the US will mainly need to stockpile processed materials. Concentrate, like crude oil, would be the ideal material for the US to stockpile if the country had sufficient domestic processing capacity.

At its peak in December 2009, the SPR held 726.6 million barrels of storage inventory (compared to 390 million barrels in December 2024).[87] This equated to roughly $51 billion in inventory value ($75 billion in 2024 dollars) at the prevailing price of $70.42 a barrel.[88] The level of stockpiled oil in 2009 covered about 75 days of net imports, 39 days of consumption, and 2.3 percent of global annual production.[89] According to the DOE, total investment in the SPR to date is approximately $25.7 billion.[90] Of that sum, about $5 billion was spent on facilities and $20.7 billion on crude oil.

Case Study #3: US SPR (cont'd)

The SPR has historically only had the authority to purchase material at index-based prices. Under the Biden administration, the DOE began experimenting with fixed-price forward contracts for acquisitions.[91] These contracts were meant to provide a guarantee that could derisk investment decisions and incentivize domestic production by providing future price certainty. Forward contracts could potentially allow both producers and the SPR to hedge risk from volatility in spot prices by mixing sales/acquisitions between forward contracts and spot purchases.[92]

Oil stockpiles are operated by the DOE, with both the president and Congress holding various decision-making authorities. While use of the SPR has been subject to partisan arguments, there is strong bipartisan consensus on the overall importance of US oil stockpiles.[93] The actual impact of stockpile releases on oil prices is more widely debated.

Analysis by the US Department of Treasury in July 2022 estimated that the Biden administration's release of over 180 million barrels of oil from the SPR following Russia's invasion of Ukraine helped lower gasoline prices by \$0.13–\$0.31 per gallon.[94] When combining SPR releases with releases of other IEA partners, the total impact on price decline was estimated at \$0.17–\$0.42 per gallon. Given US gasoline prices of around \$4.33 per barrel at the time, US and allied stockpile releases lowered prices by somewhere between 4 and 9 percent.[95]

The US experience with oil stockpiles illustrates the benefits and limitations of stockpiling. Stockpiles can support industry by offering a mechanism for increased stability. They can be managed by the public sector, with a reasonable division of responsibilities. Furthermore, material that is stockpiled can be customized to meet the needs of domestic industry. When stockpiles are released, coordination with international partners can lead to a greater impact on markets and energy security.

However, the SPR also shows that stockpiles can be politicized, particularly as they grow. For example, the Biden administration faced significant pushback when it released large volumes from the SPR after Russia's invasion of Ukraine.[96] And even when a stockpile is adequately funded, its ability to affect markets is often limited. The SPR, despite its size, only wields a small impact on the global oil market—with its much larger supply and demand—particularly when the market is not tightly balanced, which is usually the case when either a sizable withdrawal or acquisition is warranted.

Lessons Learned: Chinese, Korean, and Japanese Decisions on Stockpiling Parameters

China

Primary and Supporting Objectives of the Stockpiling System

China's mineral stockpile supports both national and economic security.[97] The stockpile is administered by the National Foods and Strategic Reserves Administration, a public agency that is part of China's National Development and Reform Commission, a ministerial-level department of the State Council.[98] The stockpile ensures that sectors of national security importance, including defense, high-tech, and energy, have sufficient reserves in case of a disruption. At the same time, the stockpile contributes to economic security and industrial activity by influencing mineral prices.

The Chinese stockpile's influence on markets helps domestic producers navigate periods of weak demand, oversupply, or rising costs.[99] For example, during the financial crisis in December 2008 and January 2009, the State Reserve Bureau (SRB) (which preceded the National Foods and Strategic Reserves Administration) bought 590,000 tons of aluminum and 159,000 tons of zinc to support the business continuity of domestic companies.[100] Several provinces took similar action: Shaanxi Province focused on zinc and lead, the Hunan city of Chenzhou bought silver, while Ganzhou city purchased tungsten and rare earths.[101]

The primary objectives of the stockpiling system in China¬—national and economic security—are intertwined with the supporting objective of protecting domestic industrial activity. For instance, when Yunnan Province built a base metals stockpile of over one million metric tons, it did so with metals from local producers.[102] Stockpiling acquisitions contributed to the preservation and buildup of domestic mining and processing capacity.[103]

China's stockpile can also influence global prices, which is a powerful geopolitical tool. When combined with other policies like domestic subsidies or output increases that flood the market, China's stockpile can harm competitiveness of mineral producers elsewhere in the world.

For example, in 2021, the National Foods and Strategic Reserves Administration announced stockpile releases, leading to a decrease in the global prices of copper, aluminum, and zinc.[104] China's ability to influence prices through its stockpile is a key challenge that policymakers in the United States, Canada, and the European Union face in ramping up their mineral capabilities.

In contrast, when the Chinese government decides to increase stockpiles, global mineral prices rise and help producers outside of China. For instance, when media reports emerged in 2022 that China was expanding its cobalt stockpiles, cobalt prices in Rotterdam rose.[105]

Critical Minerals and Processing Stages to Stockpile

Since it is the largest global producer of critical minerals, China can stockpile considerable amounts of materials at different processing stages either as a governmental stockpile or via operational stocks. Information about China's stockpiles is very limited: it is not known to what extent the country stockpiles ores or processed materials, and at what purity level. But Citigroup estimates that China held 2 million metric tons of copper, 800,000 metric tons of aluminum, and 350,000 metric tons of zinc in stockpiles as of 2021.[106] Relative to domestic consumption, this amounted to about 16.5 percent of annual use of refined copper, 2 percent of aluminum, and 5.2 percent of zinc.[107]

Baotou Steel Rare-Earth in Inner Mongolia is a notable stockpiling location for rare earths. In late 2014, the SRB built storage for more than 40,000 metric tons of rare earth oxides in Baotou.[108] This storage capacity equates to over 10 percent of global consumption.[109] The SRB also stores cobalt metal, molybdenum oxide concentrate, and tungsten concentrates at the same location.[110]

Management System

China's stockpiling system is based on a public ownership model. The National Food and Strategic Reserves Administration is responsible for stockpiles of all commodities except for oil.

China's stockpile strives to be financially self-sustaining, as it builds stocks when prices are low and sells in the global market when they are high. In 2023, for instance, Beijing took advantage of low cobalt prices to buy record volumes in two rapid deals.[111] Such a move would be difficult for the US unless appropriations already existed since congressional approvals can take up to a year.[112]

Moreover, as China is the largest producer of minerals and, in many cases, the largest consumer, commercial operational stocks are likely substantial. As many companies involved in mining and processing are vertically integrated and state-owned, commercial operational stocks are also indirectly part of the public stockpiling regime.

Trade-offs between Costs and Stockpile Depth

Based on the previously cited Citigroup estimates from 2021, Chinese stockpiles could hold approximately $18.6 billion in copper, $2.4 billion in aluminum, and $1.1 billion in zinc.[113] This dwarfs the entire US NDS, which held approximately $0.9 billion of material in 2023.[114] China has dedicated significantly more funding and attention than the United States to critical mineral stockpiling in the last two decades.

As a further example, in May 2024, China's National Foods and Strategic Reserves Administration was planning to acquire an additional 15,000 metric tons of refined cobalt.[115] Those purchases would likely cost a minimum of $412 million and comprise slightly over 6 percent of global annual cobalt production.[116]

Korea

Primary and Supporting Objectives of the Stockpiling System

Korea's critical mineral stockpile seeks to stabilize prices in case of a disruption, support domestic manufacturing, and protect national security.[117] When stockpiles are released, the minerals are typically sold at favorable prices to domestic private sector entities. To the extent possible, Korean stockpile managers try to respect companies' wishes in terms of quantities. If the demand is too high, small- and medium-size enterprises are given priority.[118]

Korea's mineral stockpile is not just used in times of crisis, but also under a business-as-usual scenario when industries have a temporary need of additional supply. In these situations, stockpiled material is lent to industry. Companies are then supposed to return the amounts they were lent shortly afterward.

The Korean stockpile supports domestic industries, especially downstream high-tech producers. Increased self-sufficiency reduces dependence on major producers like China and expands Korea's freedom of action in foreign policy.

Critical Minerals and Processing Stages to Stockpile

As of 2023, the Korean government considers 33 core minerals important, 10 of which are strategic core minerals. Core minerals have the highest supply risk and potential economic impact. A total of 35 materials will likely be subject to stockpiling moving forward,[119] including lithium, nickel, cobalt, manganese, graphite, and rare earths. The first lithium carbonate tender for stockpiling was issued in April 2024.[120] Since 2014, the Public Procurement Service (PPS), one of two stockpile managers, has been stockpiling aluminum, electrolyzed copper, zinc, lead, tin, nickel, and rare metals, among others.[121]

Management System

Mineral stockpiles in Korea are managed by two state-owned institutions: Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR) and PPS.[122] Korean stockpiles are publicly owned. The National Program for Metal (Nonferrous and Rare) Stockpiling was established in 2022, upgrading the Korean stockpiling management system and extending its size.[123] Stockpile goals have increased from 54 days of equivalent consumption in 2022 to an expected 100 days by 2031.[124] Some materials with very high risk of supply disruption (including rare earths) will be stored at more than 180 days' worth of domestic consumption.[125] Under the 54-day requirement in 2023, KOMIR managed 80,043 tons of 11 critical minerals.[126] The other public agency, PPS, maintained stockpiles of 15 minerals at nine sites across Korea, as of 2019. In the coming years, PPS will transfer nine minerals to KOMIR, as it did with cobalt in 2023.

Occasionally, the PPS makes use of the futures trading system, a hedge against future price fluctuations, which also reduces overhead costs/storage charges until delivery.[127] As Korea is a high-tech manufacturing hub, companies also hold sizable operational stocks to protect themselves against disruptions, but this happens on a voluntary basis.

To strengthen the response system, the maximum period it will take to release minerals after a disruption will be reduced from 60 days to 30. An emergency release system was also introduced in 2022, which reduces waiting time for companies to a maximum of eight days in the case of a disruption.[128] The updated release process was successfully tested in April 2023 by KOMIR and Korean steelmaker POSCO.[129]

Trade-offs between Costs and Stockpile Depth

The Korean stockpile depth varies for different materials: materials encountering the highest risks can be stored at 180 days' worth of consumption, while others are only at around 100 days. There is limited public information about which specific materials are stockpiled for exactly how many days. The Korean stockpile likely consists of many intermediate or refined products, like rare earth metals, electrolyzed copper, and lithium carbonate, that can be used by downstream industries without much additional processing. To facilitate an expected increase in stockpiles from 2024 to 2026, KOMIR and the state-owned Saemangeum Development and Investment Agency are investing $185.7 million in a new storage facility of 112 square meters at Saemangeum National Industrial Complex.[130]

Japan

Primary and Supporting Objectives of the Stockpiling System

The Japanese government operates one of the world's oldest and most comprehensive policy architectures for securing supplies of critical minerals. Stockpiles are used both in the case of a national (security) emergency and as an economic buffer to balance prices and support the domestic industry, especially for high-tech firms.

The economic objective of Japan's stockpiling system is reflected in the close historical relationship between the government and its domestic high-tech industry.[131] The Japanese government noticed as early as the 1980s rising demand for minerals like tungsten, cobalt, and vanadium to sustain its growing technology industry. To mitigate potential risks, a private stockpiling system was established in 1982, followed by a public one a year later.[132] National security interests became more integral to Japan's mineral strategy and its stockpiling system after 2010, when a dispute with China over rare earths marked a turning point in Japanese thinking around minerals and provided further impetus for strengthening stockpiling policies.[133]

Critical Minerals and Processing Stages to Stockpile

The first Japanese stockpiling system included seven minerals and followed targets set in 1986.[134] It aligned with the country's first list of critical minerals, released in 1984 under the Ministry of International Trade and Industry, the predecessor of the Ministry of Economy, Trade, and Industry (METI).[135] As of 2020, the public stockpile aims to include 34 materials.[136]

Japan used to stockpile about 60 days of consumption—18 days held by private companies and 42 by Japan Oil, Gas, and Metals National Corporation (JOGMEC).[137] In 2020, the government announced the ambition to stockpile approximately 60 days of consumption in the public stocks alone, in addition to private stocks.[138] But the new target is flexible:[139] for materials with high geopolitical risk, the target is as high as 180 days;[140] for materials with lower risk, the target could be lower.

Management System

Japan's stockpiling strategy is based on a public and a private system. JOGMEC is responsible for stockpiling efforts and is part of METI.[141] While information about public releases of metal stockpiles is limited, METI decides to release certain parts of existing stockpiles and instructs JOGMEC to do so. This may happen in the case of a supply disruption or in consultation with the market, if there is a need to alter the forms of stockpiled minerals.[142]

The Committee for Policy Evaluation, consisting of independent experts, is tasked with assessing the market impact of stock releases, before and after the release. Apart from public stockpiles, private actors are encouraged to maintain stockpiles based on a voluntary stockpiling target of 18 days' worth of consumption.[143] The target for private stockpiling includes operational inventories that companies would normally hold rather than being an additional amount.[144] Reporting on the type and size of stocks by companies to METI is also voluntary, and companies are free to use the stocks whenever they see fit.[145]

Trade-offs between Costs and Stockpile Depth

In addition to the public stockpile financed by METI, the Japanese system mobilizes private sector involvement as a comprehensive solution to short-term disruptions. Even though JOGMEC decided to stockpile a large variety of materials, the stockpiling targets depend on the supply risk of a given material.

Stockpiling Lessons Applied to the Five Choices

The critical mineral stockpiling strategies of China, South Korea, and Japan offer insights for US policymakers as they consider how to design and implement a stockpiling system.

Choice 1: Objectives of the Stockpiling System

A common feature of all three nations' stockpiling systems is their dual focus on national security and economic stability, as opposed to the US, which has historically prioritized defense-related objectives.

These countries' stockpiling systems also collaborate closely with industry. In South Korea, for instance, stockpiled materials are lent to companies facing short-term shortages, and in China, state-owned enterprises are tightly integrated into the stockpiling regime. The US could consider a deeper public-private alignment, working closely with strategic sectors to ensure stockpiling efforts meet both public and private needs.

Finally, for China, South Korea, and Japan, reducing reliance on adversarial suppliers is a key driver of stockpiling strategies. Stockpiles also provide geopolitical leverage, as seen in China's ability to influence global mineral prices through strategic releases or purchases.

Choices 2 and 3: Selection of Critical Minerals and Processing Stages

While details about the materials stockpiled by China, South Korea, and Japan are mostly undisclosed, all three countries maintain extensive lists of critical minerals tailored to their strategic needs. China also has flexibility to stockpile minerals at various processing stages, given its domestic processing capacity.

All three countries have attempted to maintain flexibility to respond to evolving technological demands and geopolitical risks. A US stockpiling system would also need to be regularly updated to reflect changes in supply chain vulnerabilities and emerging technologies.

Choice 4: Management of Stockpiles

China, South Korea, and Japan rely on publicly owned and managed stockpiles, although their approaches vary. China's stockpiling system blurs the lines between public and industrial stockpiles due to the state ownership of many companies. South Korea's system is government-led, but some private companies hold voluntary stocks to complement public reserves. Japan employs a hybrid model that integrates public and private responsibilities for stockpiling, in addition to a separate committee that is tasked with mitigating market disruption.

The US could adopt a similar mixed approach by combining publicly managed reserves with (at least) voluntary private stockpiles to balance government control with private sector efficiency. Additionally, South Korea's practice of lending stockpiled materials to industries during noncrisis periods offers a model for increasing the utility of stockpiles. The Japanese system shows the importance of understanding potential market impacts before deciding to release or build stock.

Choice 5: Balancing Costs and Stockpile Depth

Japan and South Korea tailor stockpile depth to the strategic importance and risk profile of each material. Japan, for example, targets up to 180 days of stockpile coverage for high-risk materials. South Korea employs a similar approach, with material-specific flexibility.

Funding mechanisms also play a crucial role in these stockpiling systems. China's ability to use a buy-low, sell-high strategy minimizes fiscal burdens. South Korea reduces overhead costs through futures contracts, which also help mitigate price volatility.

Conclusion and Policy Recommendations

A new US critical mineral stockpiling system could enhance the supply and stability of minerals used in national defense, energy, and other key industries. However, building such a stockpile comes with significant design and implementation challenges. A successful effort will require clarity of purpose, strategic alignment between stakeholders (including the private sector, allied countries, and opposing political parties), and substantial investment.

At the heart of building a stockpiling system are five critical choices: defining objectives, selecting minerals, determining processing stages, establishing an effective management system, and balancing costs with stockpile depth. A well-functioning critical mineral stockpile will demand bipartisan consensus. Both political parties will have to collaborate on a long-term vision and ensure adequate funding is appropriated into the future.

The stockpiling strategy must reflect the unique risks and opportunities associated with each mineral. High-risk materials may require deeper stockpiles. And public spending will have a larger impact on minerals with small market sizes. Beyond defense objectives, material-specific targets could be aligned with evolving technologies and market dynamics to optimize resource allocation. This nuanced approach could be accompanied by clear standards for sourcing, which could incentivize responsible producers to invest in new greenfield projects.

Balancing costs is perhaps the most pressing challenge. The authors estimate that an economic stockpile, designed to stabilize markets and support key industries, could cost at least six times more than a defense-oriented stockpile. These costs will likely escalate as global demand for critical minerals rises sharply toward 2040. The US can manage the financial burden of stockpiling by adopting innovative approaches, such as cautiously leveraging buy-low, sell-high strategies, employing more flexible purchasing tools like AMCs and APAs, and exploring public-private partnerships to share costs with industry.

Based on findings in this report, the authors recommend the following steps for US policymakers considering the establishment of a critical minerals stockpile:

Choice 1: Objectives

- The US government and Congress could ensure that the stockpile maintains a focus on national defense but provide the agency managing the stockpile with discretion (or the ability to appeal to Congress) to operate an economic stockpile for certain materials when there is strategic and budgetary rationale.

  - Congress could increase funding for the stockpile with the priority of ensuring adequate material for defense purposes. The NDS currently falls short of its core purpose, exposing the US to national security vulnerabilities.
  - Congress could set up a bipartisan task force to evaluate the feasibility, costs, and management of expanding defense stockpiles to deal with economic security, steering clear of costly minerals that lack firm bipartisan consensus.
  - Congress could more immediately provide the managing agency of the stockpile with the ability to build economic stockpiles for very specific materials when they align with US national security interests, are budgetarily feasible, and are coordinated with other relevant agencies. Certain highly strategic, niche materials like gallium and germanium may be candidates for such an approach.

- Stockpile managers could be given the relevant authorities, and a mandate, to use government purchasing to promote broader US strategic objectives.
  - Where possible, purchases could prioritize materials sourced from environmentally and socially responsible suppliers. By setting clear criteria for the stockpile, the US can incentivize higher standards for mining and processing projects seeking to sell into the stockpile.
  - Stockpile managers and Congress could evaluate the use of purchasing authorities like forward contracts, AMCs, and APAs to facilitate more domestic mineral production. Innovative acquisition strategies can provide a compelling advantage to projects as they seek to raise capital and enter production.

Choice 2: Minerals to Stockpile

- A US stockpile could first prioritize building stockpiles in key defense-oriented materials.
- A stockpile can then target economically relevant niche materials where there is strategic merit and budgetary feasibility.
- Materials in larger markets that have less supply risk and are more costly, such as copper cathode or rods, are generally not good choices for stockpiling in large quantity.

Choice 3: Processing Stage to Stockpile

- Generally, a US stockpile could decide, long term, to hold concentrate or intermediate products, given lower costs, easier technical feasibility, and more flexibility for processing into different end products by domestic processing facilities.
- The lack of domestic processing capacity for certain materials today, though, may require stockpiling processed materials in the near term and even the medium term, until the US and its allies build domestic processing capacity to produce the high-purity materials needed in key defense, energy, and manufacturing applications.

Choice 4: Stockpile Management System

- The US can continue to follow a publicly managed stockpiling model, but perhaps one led by a new agency that is able to operate more independently and cost-efficiently, like in Japan and Korea.
- Voluntary industry stocks could be further encouraged by the government and promoted through industry convenings, potentially organized by the stockpiling agency in conjunction with entities such as the Department of Commerce. A public stockpiling agency could provide recommendations to this extent, with industry having the prerogative to make decisions based on that.

Choice 5: Costs

- US policymakers should be aware of the limitations of stockpiles to manage market failures.
- Stockpiles can serve as an emergency response tool but are not an efficient way to correct long-term issues of market concentration, volatility, or systemic over/undersupply for most commodities. Policymakers could focus on more practical tools, such as permitting reform and financial instruments, when it comes to issues like threats in copper supply or worries over the geographic concentration of lithium processing.
- But in specific cases, such as with niche materials like gallium, germanium, and rare earths, stockpiles can be an economically feasible way to stretch beyond defense needs and create a market fabric conducive to US energy security. This can primarily be achieved through forward contracts, AMCs, APAs, or by developing enough capacity for a stockpile to act as a swing consumer/producer.

Notes

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