Highlights of GAO-26-108687, a report to congressional requesters

July 2026

Why GAO did this study

The U.S. considers 60 minerals as critical because they are essential to the nation's economy or security and have supply chains vulnerable to disruption.

Several critical minerals are key to the functioning of batteries and semiconductors, which have applications in electric vehicles, stationary grid energy storage, consumer electronics, and the defense industry. For example, lithium is a key component of modern batteries that are both lightweight and energy-dense. Semiconductors rely on the unique electrical properties of critical minerals such as gallium, germanium, arsenic, and indium.

U.S. executive and legislative branch policymakers have a long-standing goal to reduce critical mineral import reliance, through technological innovations and other approaches.

This report examines: (1) substitution and recycling technologies to reduce import reliance on critical minerals within the battery and semiconductor industries, (2) challenges to the development and adoption of these technologies, and (3) policy options to support reducing reliance.

To conduct this technology assessment, GAO interviewed federal officials and experts and reviewed academic papers, agency and expert documentation, and federal policy. GAO identified four policy options in this report (see next page).

View GAO-26-108687. For more information, contact Sarah Harvey at HarveyS@gao.gov.

TECHNOLOGY ASSESSMENT

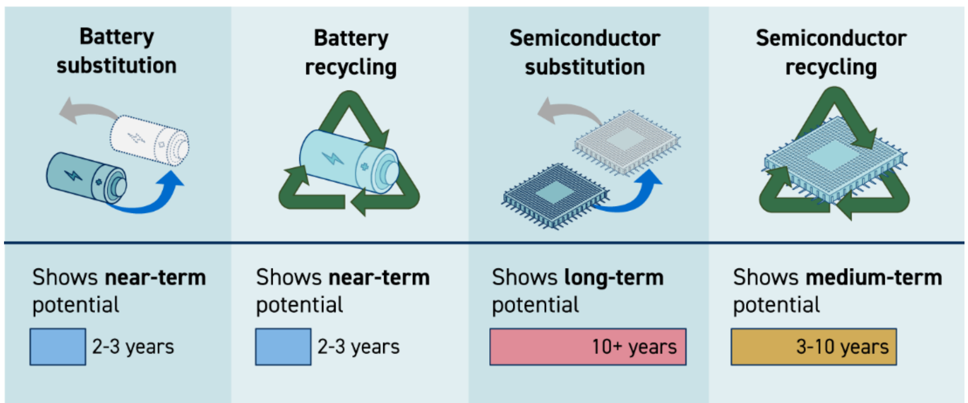
Critical Minerals

Reducing U.S. Import Reliance with Substitution and Recycling Technologies

What GAO found

Technologies like batteries and semiconductors are essential to the U.S. economy but rely on imports of lithium, gallium, and other critical minerals. GAO found that substitution and recycling technologies could help reduce U.S. reliance on these imports. But progress is likely to take many years in some cases.

Potential for technologies to reduce critical mineral import reliance



Source: GAO (analysis of agency and expert information and literature; illustrations). | GAO-26-108687

For batteries, substitution and recycling technologies offer near-term potential. For example, using lithium iron phosphate batteries for stationary grid energy storage might reduce imports of cobalt, manganese, and nickel in the next 2 to 3 years. But these batteries do not perform as well in other applications, like long-haul electric vehicles, due to their lower energy density. Lithium-free batteries are not yet commercially mature. Battery recycling technologies are mature and offer a pathway to reduce imports for copper, cobalt, lithium, and nickel in 2 to 3 years. These technologies aim to recover critical minerals at high rates through chemical leaching and smelting. Experts told GAO, however, that U.S. battery recyclers lack capacity. Additionally, available inputs for recycling (referred to as feedstock) are often landfilled or exported for processing.

For semiconductors, most substitution and recycling technologies are likely years away from maturity. Substitution is unlikely to have a near-term effect on import reliance of minerals, such as gallium and indium, because other materials do not perform as well as these critical minerals across the same conditions. Experts told GAO that industry will not adopt substitutes until they can perform at the same level as current semiconductor materials in the intended application. Technologies to recycle minerals from semiconductors also face challenges, such as an underdeveloped market. Semiconductor manufacturing scrap is a potential source of recycled minerals, though this is not yet standard practice in the U.S. Discarded electronics are another potentially large source, but their critical mineral content is low, and those minerals are generally mixed and bonded with other materials. Technologies to recycle this form of electronic waste are in pilot-stage development.

GAO identified four policy options that could support the goal of reducing critical mineral import reliance and help address challenges to recycling and substitution technologies. These options identify possible actions by policymakers, which include legislative bodies, government agencies (federal, state, and local), academia, standards-setting organizations, industry, and other groups. In general, these technologies have potential, with policy action, to reduce some of this reliance in the near, medium, or long term. See below for details on these options.

Policymakers could also choose to pursue non-technological policy approaches, such as increased domestic mining. Many non-technological approaches are the subject of current and proposed legislation and executive action (see report p. 6).

Policy options to support reducing critical mineral import reliance and address challenges to substitution and recycling technologies

Policy options	Potential implementation approaches	Opportunities and considerations
Establish domestic manufacturing capacity for viable substitutes (report p. 23) Policymakers could consider building or repurposing existing manufacturing capacity to produce substitute technologies for batteries and semiconductors.	• Providing support for private capital investments in manufacturing plants for commercially available battery technologies. • Establishing facilities or partnerships to perform pilot-scale testing of semiconductor substitutes.	• Domestic manufacturing capacity could allow for near-term production of commercially available substitute technologies like lithium iron phosphate batteries, which could reduce import reliance on critical minerals like cobalt and nickel. • Battery and semiconductor production facilities are costly and tend to be specialized for the production of a particular technology.
Establish domestic recycling capacity (report p. 24) Policymakers could build domestic infrastructure to bolster the domestic capacity to recycle batteries and semiconductors.	• Providing support for private investment in factories for new battery recycling. • Collecting and sharing data on manufacturing scrap and end-of-life devices containing batteries and semiconductors. • Reviewing and streamlining permitting requirements and hazardous waste designations.	• Expanded domestic infrastructure could reduce or eliminate the need to ship partially processed batteries overseas for recycling. • Building domestic recycling infrastructure may not reduce import reliance for selected critical minerals in the near term, since building new or repurposing existing infrastructure can take a decade or more and require significant investment.
Secure inputs for recycling (report p. 25) Policymakers could support efforts to collect, sort, transport, and store manufacturing scrap and end-of-life devices for recycling and reuse.	• Establishing and overseeing national and local electronic waste collection programs that provide education and resources (e.g., drop-off locations) for consumers. • Providing financial incentives for industry to collect or retain manufacturing scrap and end-of-life devices for recycling.	• Securing a consistent supply of inputs for recycling and reuse could help reduce the need for critical mineral importation in the near term. • Although mature battery recycling technologies exist, securing additional inputs may exacerbate challenges related to the safety, transportation, and handling of hazardous materials. • Without demand and competitively priced recycled semiconductor materials, it may be difficult for recyclers to scale their operations and offset the amount of imported minerals required in the near term.
Support research, development, and testing (report p. 25) Policymakers could continue or grow support for research, development, and testing of substitution and recycling technologies.	• Supporting research to improve performance of lithium-free batteries. • Supporting research into battery recycling technologies that reduce or avoid the cost, waste issues, and environmental impact of current techniques. • Encouraging targeted materials research focused on semiconductor substitutes that maintain or enhance material performance and reduce the use of critical minerals when possible. • Supporting research on more efficient semiconductor recycling technologies that recover more critical minerals.	• Increased research could help overcome current limitations of existing technologies, resulting in better performance (e.g., higher energy density batteries, larger bandgap semiconductors) or higher commercialization potential (e.g., improved recovery of minerals from semiconductors). • Research, development, and testing efforts may not yield mature technologies in the near term.

Source: GAO. | GAO-26-108687