

An aerial photograph of a massive open-pit mine. The mine's terraced walls show various geological layers in shades of brown, tan, and grey. A wide, light-colored dirt road winds through the center of the mine. A single yellow dump truck is visible on this road, providing a sense of scale to the enormous excavation. The sky is not visible, as the mine's walls fill the upper portion of the frame.

S&P Global Energy

SEG Market Report

Samarium (Sm), Europium (Eu) and
Gadolinium (Gd) oxides

October 2026

Preamble

This draft SEG Market Report aims to increase transparency across the samarium (Sm), europium (Eu), and gadolinium (Gd) oxide markets, helping public and private stakeholders make more informed investment decisions across the commodity lifecycle. Sm, Eu, and Gd support a broad range of strategic applications, including permanent magnets, phosphors, nuclear technologies, medical imaging, and advanced materials. As critical inputs for defense, aerospace, healthcare, electronics, and energy applications, secure access to SEG oxides is becoming increasingly important for supply chain resilience.

Unlike NdPr, SEG oxides are typically produced as by-products during rare earth separation, meaning production is often driven by demand for other rare earth products rather than SEG market fundamentals. As a result, these markets are often characterized by limited transparency, concentrated supply chains, and constrained production flexibility. This report outlines key supply chain bottlenecks, resiliency challenges, and the market signals needed to support a more robust and diversified supply base. To support this assessment, S&P Global has conducted a bottom-up, asset-level analysis of SEG oxide production costs, providing an independent view of supply economics and helping identify the marginal suppliers required to meet demand in a structurally tight market. This analysis reflects a multi-year effort combining bottom-up asset modelling, proprietary market intelligence, extensive research, expert assumptions, and industry consultation to overcome significant data limitations across these opaque mineral value chains.

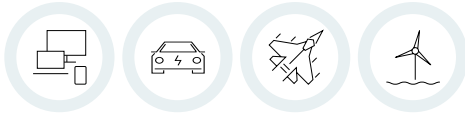
The market values in this report represent a fundamentals-based assessment of the cost and the break-even range required for Sm, Eu, and Gd oxides production sources to remain economically viable and meet sufficient G7+Australia demand. This enhanced cost transparency can facilitate better-informed offtake agreements and investments throughout the supply chain. However, actual transactions also factor in inventory levels, broader market conditions, global trade dynamics, and other variables not included in this analysis.

These values are different from the spot market price assessments published by Platts, part of S&P Global Energy ([link](#)).

Given the limited availability of public data, this report is based on S&P Global's proprietary market and mineral intelligence and our analysis of company disclosures, and market information. We welcome input from market participants to support the ongoing refinement of future editions.

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Key Takeaways

- For Samarium (Sm), europium (Eu), and gadolinium (Gd), collectively known as SEGs, S&P Global estimates structural cost ranges of \$3-4/kg Sm oxide, \$35-42/kg Eu oxide, and \$28-31/kg Gd oxide by 2028 to support ~873 metric tons (t) Sm, ~24 t Eu, and ~418 t Gd production under a more geographically diversified supply base. Cost allocation remains highly price-dependent, while prices remain elevated due to tight availability.
- Global demand is projected to grow ~47%, ~22% and ~33% from 2025 to 2030 for Sm, Eu, and Gd, respectively, driven mostly by defense permanent magnets (Sm), phosphors and lighting (Eu), and consumer electronics (Gd).
- By 2028, resilient mined SEG production¹ could reach ~13,000 t, more than double global demand. However, nearly half of SEG content is likely to remain in mixed SEG+ products, as many refineries prioritize their core rare earth products rather than small SEG markets. Coupled with reduced utilization during ramp-up, this limits separated 2028 production to ~1,030 t Sm, ~27 t Eu and ~490 t Gd, equivalent to ~79%, ~46% and ~83% of G7+ Australia demand, respectively.

Introduction

Samarium (Sm), europium (Eu), and gadolinium (Gd), collectively known as SEGs, are rare earth elements (REE) with diverse end-use markets spanning defense, industrial, electronics, healthcare, power generation, and consumer applications. Sm is consumed in samarium-cobalt (SmCo) magnets, Eu in phosphors, and Gd in consumer appliances, road mobility, and industrial equipment.

SEGs are often marketed as mixed concentrates, either as SEG or broader SEG+ products containing additional REE. Producing separate oxides requires additional processing, and the relatively small size of these markets means producers often focus on higher-value REEs. Consequently, SEGs are commonly sold as a mixed product, with supply of individual elements dependent on downstream separation capacity and economic incentives.

Sm, Eu, and Gd oxide supply is highly concentrated in China. This concentration was demonstrated by China's export controls, with Sm and Gd included in the first wave of licensing requirements in April 2025 and Eu expected to follow in November 2026². While controls have effectively halted exports of Sm and Gd products to the US and Japan, China continues to approve selected shipments to other destinations (notably Austria in July 2026).

Following the introduction of export controls, Sm and Gd oxide prices rose from ~\$3/kg Sm to \$800/kg Sm and ~\$30/kg Gd to ~\$3,000/kg Gd, respectively, by August 2026. Prices also remained substantially above Chinese levels (\$100/kg Sm and \$600/kg Gd), increasing interest in SEG separation capacity outside the dominant market³.

Properties

Sm-Co Curie temperature:
700-850 °C



Higher demagnetization temperature than NdFeB magnets

Red emission wavelength of Eu³⁺
~610-618 nm



Produces highly pure red light, essential for phosphors in displays, LEDs, and lighting

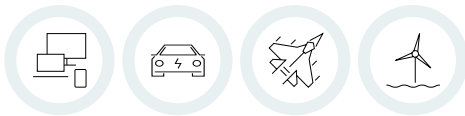
Gd neutron absorption cross section
~49,000 barns



Highest of any naturally occurring element, used in nuclear reactors, radiation shielding

1. Resilient supply excludes China, Russia, and North Korea as suppliers; 2. [PLATTS: China Data: Rare earth exports drop 17% MOM](#), Platts, July 2026; 3. [North American neodymium-praseodymium slips on month amid pre-restocking lull](#), Platts, August 2026. Demand beyond dominant market comprises global demand excluding China.

Sources: S&P Global Analysis for Dy and Tb supply, demand and costs; USGS (Rare Earths 2026 Commodity Summary); Platts prices



Sm, Eu and Gd demand

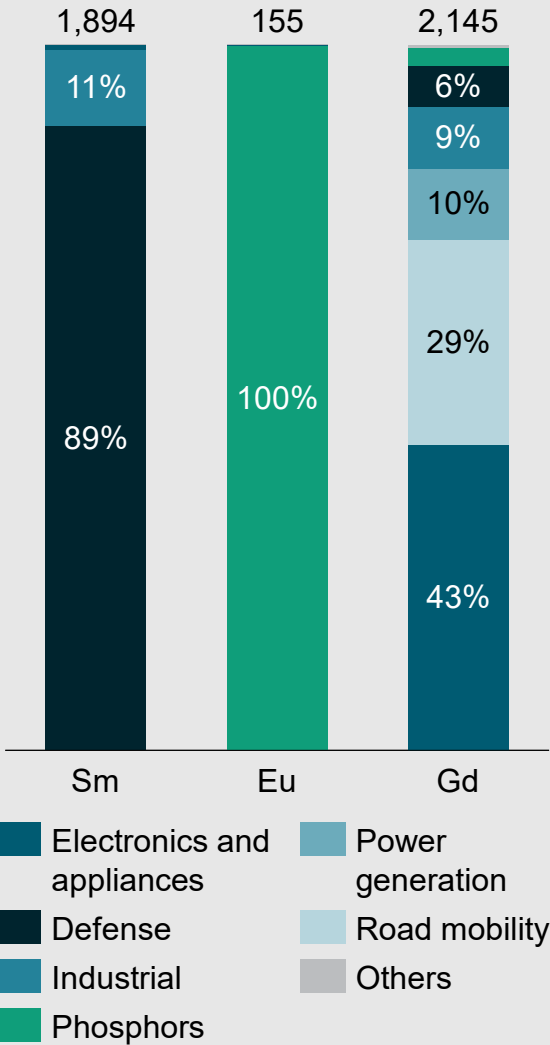
Sm, Eu, and Gd oxide demand spans strategic defense, industrial, electronics, healthcare, power generation, and consumer applications. Sm demand is primarily driven by SmCo magnets used in defense. Eu demand is concentrated in phosphors for flat-screen displays and lighting. Gd demand is diversified across consumer appliances, road mobility, power generation, defense, industrial equipment, and permanent magnets.

Global Sm, Eu, and Gd oxide demand is projected to increase from ~4,194 t SEG in 2025 to ~7,685 t SEG by 2035. Sm defense applications account for ~64% of total incremental demand over the period. Between 2025 and 2035, Gd demand is expected to increase by ~64%, from ~2,145 t Gd to ~3,520 t Gd, including a ~3.5x increase in industrial equipment demand, while Eu demand rises more steadily from ~155 t Eu to ~218 t Eu.

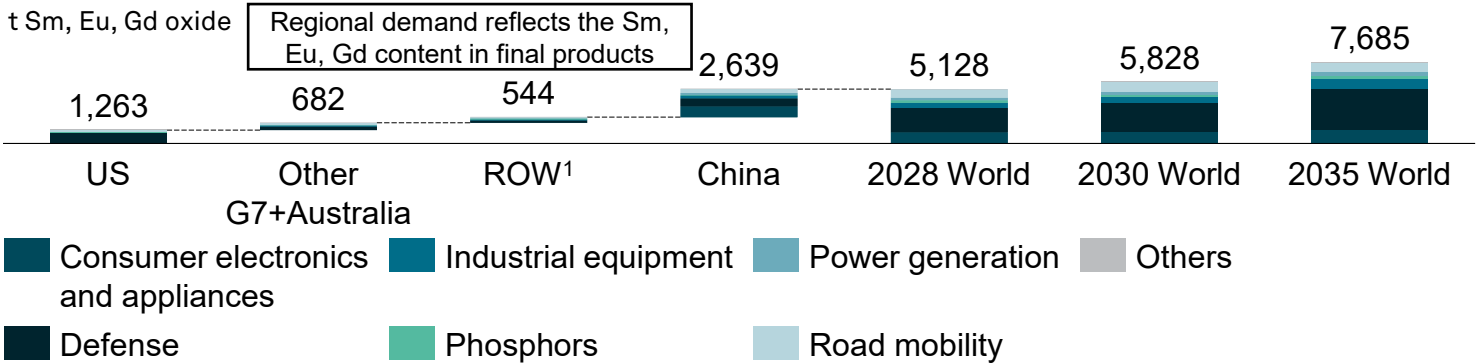
Regional demand patterns reflect the strategic nature of key end uses. The US was the largest Sm consumer in 2025, with ~40% of demand, driven by defense and aerospace applications. China was the largest Eu and Gd consumer in 2025, accounting for ~24% and ~70% of demand, respectively, supported by its leading position in consumer electronics and phosphors.

Substitution potential is particularly limited in defense and aerospace applications. SmCo magnets are used in missiles, aircraft, radar systems, and other high-temperature environments, often operating above ~300°C where conventional magnet technologies cannot maintain comparable performance, reinforcing the strategic importance of Sm and Gd supply.

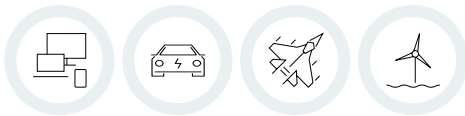
Uses of SEG 2025 (t of oxide)



SEG end-use demand outlook 2028 - 2035



1. Rest of World
Sources: S&P Global Analysis



| Sm, Eu, Gd supply

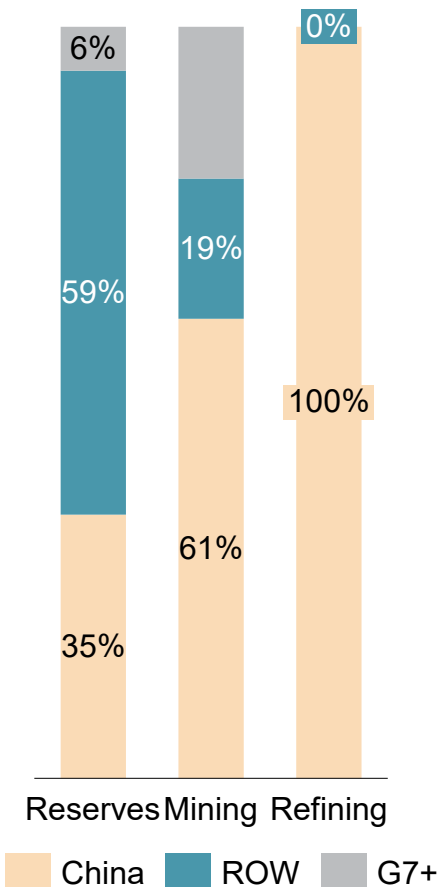
SEGs are recovered from a range of REE feedstocks, including bastnäsite, monazite, xenotime, ion-adsorption clays, and other hard-rock deposits. Unlike NdPr, which is produced by most REE projects, economically significant SEG production is associated with deposits containing high concentrations of medium and heavy REE.

Many REE operations produce SEG-bearing material, but relatively few separate individual Sm, Eu, and Gd oxides. By 2030, approximately 40% of SEG supply outside of the dominant market¹ (2,900 t) is expected to be marketed as mixed SEG concentrate rather than separated products. Producing individual oxides requires specialized solvent extraction circuits and additional processing steps, contributing to a highly concentrated separation and refining industry dominated by China, which accounts for 100% of global production in 2025.

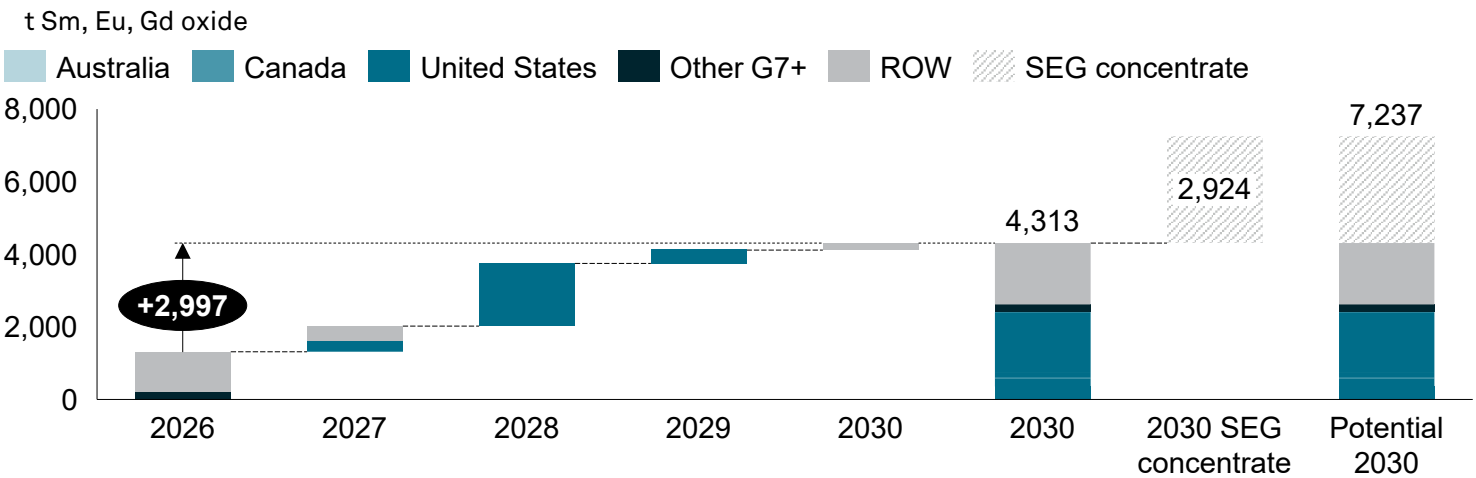
Outside China, Lynas Rare Earths (Malaysia) is the only producer to have publicly confirmed production of Sm oxide at commercial scale (since March 2026). Gd oxide is included in Lynas' planned expansions, while Eu oxide remains subject to future commercial justification. While facilities such as Solvay's La Rochelle possess separation capability, publicly disclosed production of Sm, Eu, or Gd oxides remains limited.

By 2030, 8 new and expansion projects could add 3,000 t of resilient Sm, Eu, and Gd oxide. Momentum is building across the sector, with Ucore's Alexandria recently securing more government support for Sm, Eu, and Gd products, while Energy Fuels' White Mesa Mill plans to add dedicated Sm, Eu, and Gd separation capacity through its expansion.

Market Structure (2025)²



Resilient Sm, Eu, Gd oxide announced refining capacity¹



The supply chart represents potential risked supply pipeline based on company announcements

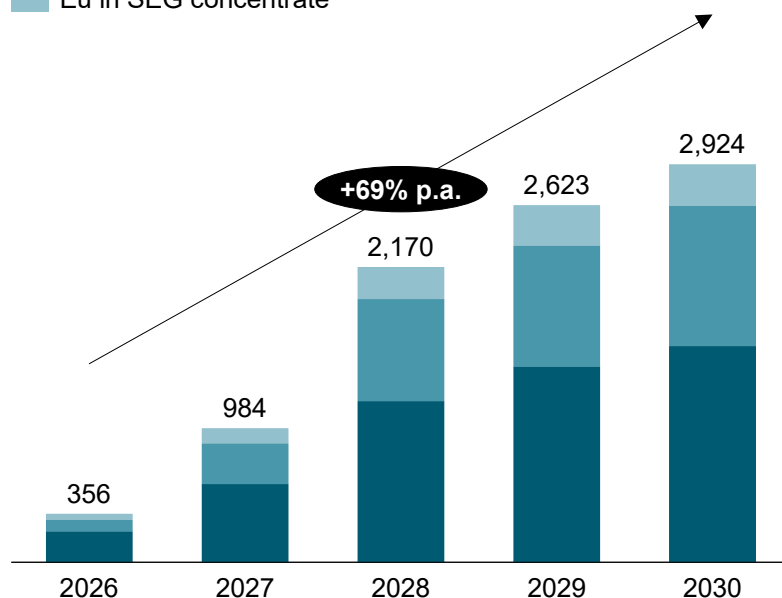
1. The supply analysis excludes assets located in Russia, China, and North Korea, as well as any assets worldwide that are majority-owned by Chinese companies;
2. Reserves and mining figures are reported on an REO-equivalent basis, while refining figures are reported as contained SEG oxide equivalent

Sources: S&P Global Analysis

Resilient SEG concentrate announced capacity^{1,2}

t Sm, Eu, Gd oxide

Sm in SEG concentrate Gd in SEG concentrate
Eu in SEG concentrate



- Mixed SEG concentrate represents potential future Sm, Eu, Gd resilient oxide supply, subject to additional separation capacity investment.
- By 2030, mixed SEG+ production could contain ~2,924 t of Sm, Eu, and Gd. Much of this material is expected to remain unseparated because many refineries prioritize their core rare earth products over the relatively small SEG markets.
- Part of this material is expected to remain unseparated or be stockpiled pending downstream processing investment, as demonstrated by MP Materials' stockpiling of SEG+ concentrate for future separation operations.

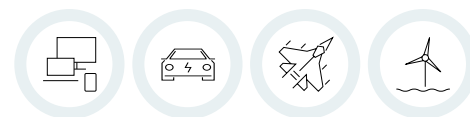


Recent market events

- Ucore's Louisiana facility received additional \$4.6 million from the US Department of Defense to advance commercial refining of Sm and Gd oxide products [Ucore, September 2026].
- Energy Fuels committed \$104 million to expand the White Mesa Mill, including circuits for separated Sm, Eu, and Gd production targeted for 2027-2028. [Platts, July 2026].
- Solvay and Viridis signed a letter of intent (LOI) to establish a long-term supply chain by 2028, routing ionic clay rare earth feedstocks from Viridis's Colossus mine in Brazil to Solvay's La Rochelle refinery in France. The feedstock contains "an important distribution" of Gd and Sm [Solvay, June 2026].
- Lynas Rare Earths achieved first commercial production of Sm oxide at its Malaysia facility in March 2026, following investments to expand heavy rare earth separation capacity. Gd oxide is included in Lynas' planned heavy rare earth separation flowsheet, while Eu oxide remains subject to future commercial justification [Lynas, June 2026].
- Rainbow Rare Earths advanced development of a phosphogypsum-based rare earth processing project expected to produce approximately 600 tpa of a product containing samarium, europium, and gadolinium, alongside NdPr oxide [Platts, March 2026].

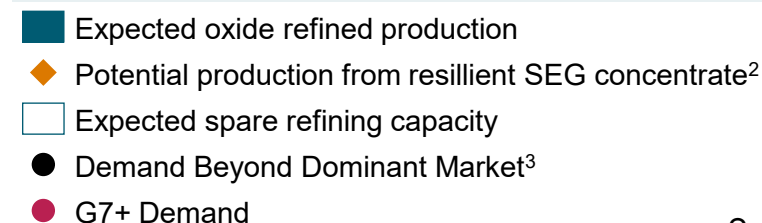
1. The supply analysis excludes assets located in Russia, China, and North Korea, as well as any assets worldwide that are majority-owned by Chinese companies; 2. Sm, Eu, and Gd volumes within SEG concentrate are estimated using the rare earth element distribution of each project's reported feedstock grade.

Sources: S&P Global Analysis for Sm, Eu, Gd supply, demand and costs



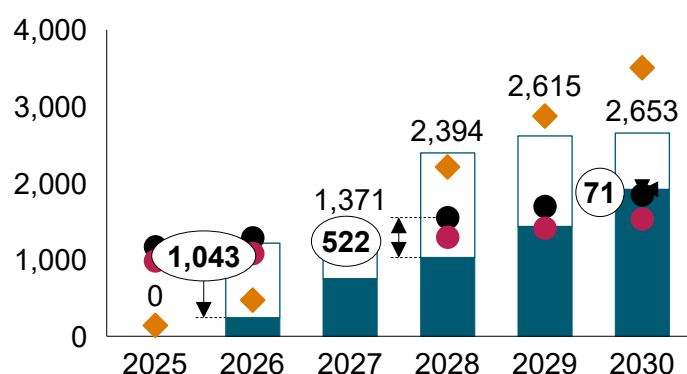
Supply-demand balance

Supply-demand balance of resilient supply¹



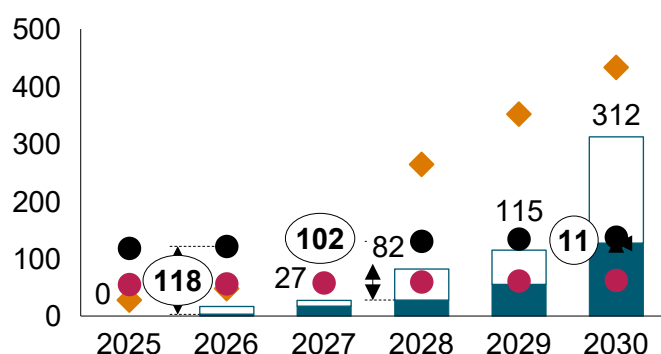
Mixed SEG+ products represent a significant source of future supply that could surpass demand if separated, creating potential downward pressure on prices.

t Sm oxide



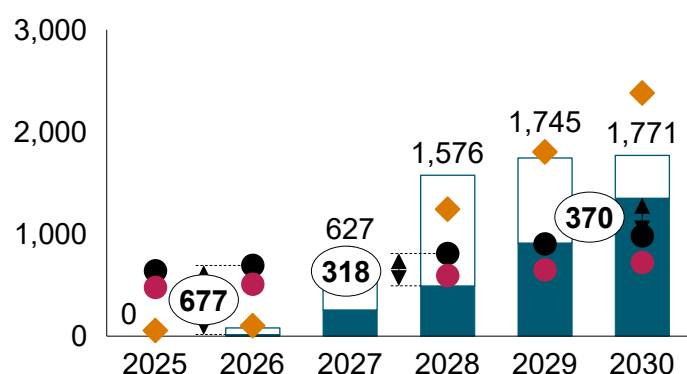
- Sm oxide capacity and production are expected to grow through the forecast period, although average utilization remains around 49% as new capacity ramps up.
- By 2028, announced resilient Sm oxide production reaches 1,026 t against ~1,500 t of demand outside the dominant market, with spare capacity that could bridge the gap.
- By 2030, announced production reaches ~1,900 t, surpassing demand outside the dominant market by ~100 t.

t Eu oxide



- Eu oxide capacity and production are expected to grow through the forecast period, although average utilization remains around 41% as new capacity ramps up.
- By 2028, announced resilient Eu oxide production reaches 82 t versus ~130 t of demand outside the dominant market. Closing the gap would require additional SEG separation capacity.
- By 2030, announced production reaches 127 t, ample for G7+ demand but ~10 t short of total demand beyond the dominant market.

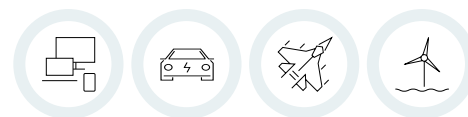
t Gd oxide



- Gd oxide capacity and production are expected to grow through the forecast period, although average utilization remains around 44% as new capacity ramps up.
- In 2028, announced resilient Gd oxide production reaches ~490 t, while demand outside the dominant market is ~800 t. The resulting gap could be bridged through spare capacity.
- By 2030, announced production reaches 1,350 t, surpassing total demand beyond the dominant market by 370 t.

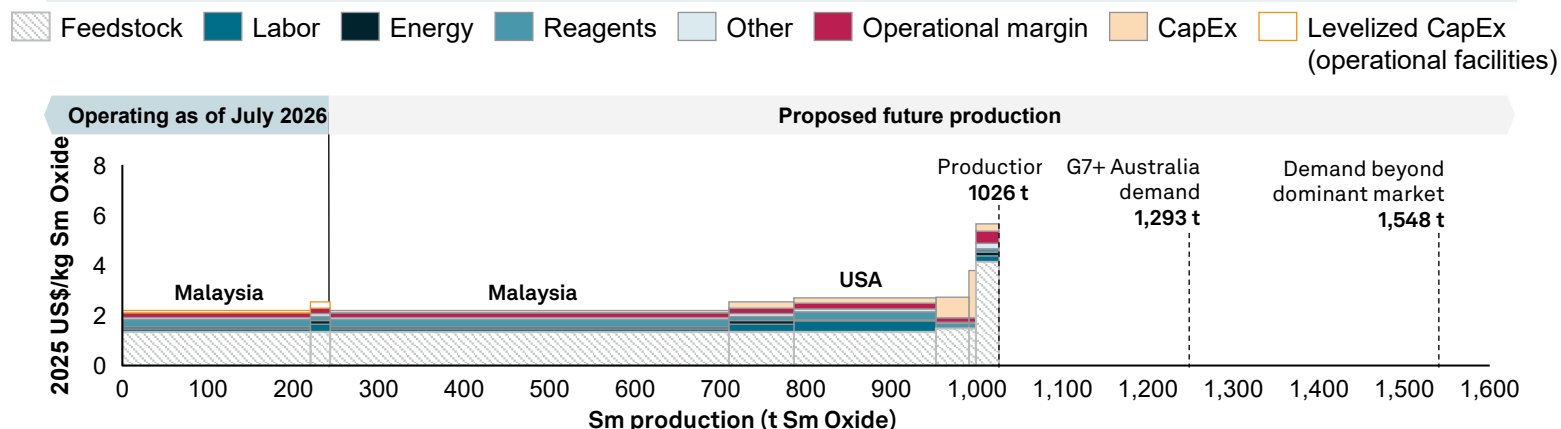
1. The supply analysis excludes assets located in Russia, China, and North Korea, as well as any assets worldwide that are majority-owned by Chinese companies. 2: Based on SEG concentrate being refined into Sm, Eu, and Gd oxides rather than marketed as concentrate; 3. Demand beyond dominant market comprises global demand excluding China.

Sources: S&P Global Analysis; Platts prices

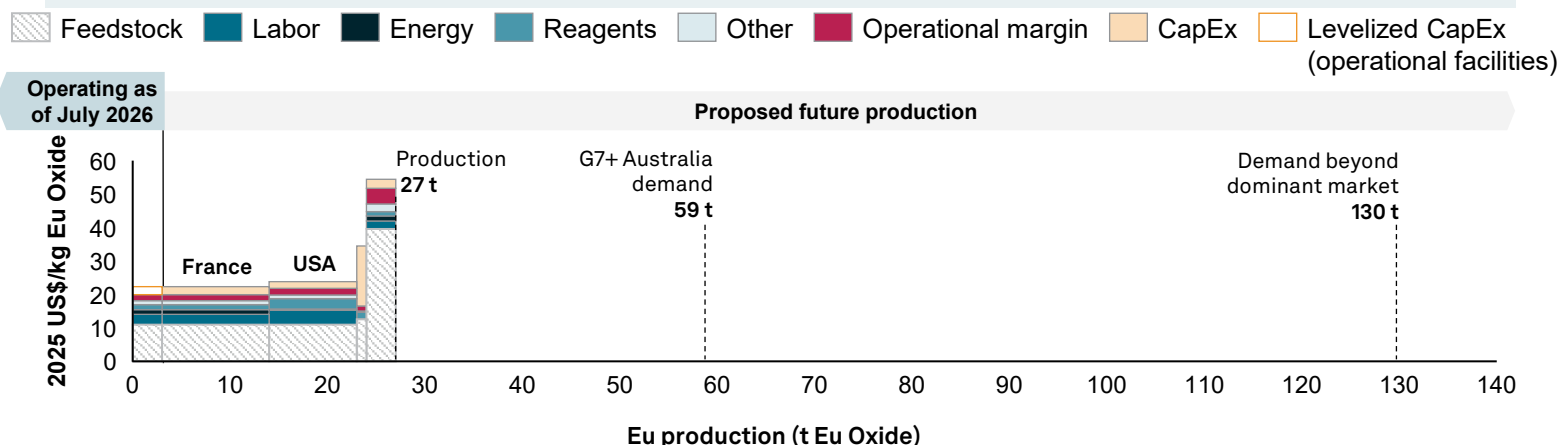


Structural Cost: Represents the full cost required for an asset to achieve its target return on investment, assuming projects are developed in line with announced timelines and operate at expected utilization rates². This cost considers an unrisks projection subject to normal industry attrition and delays.

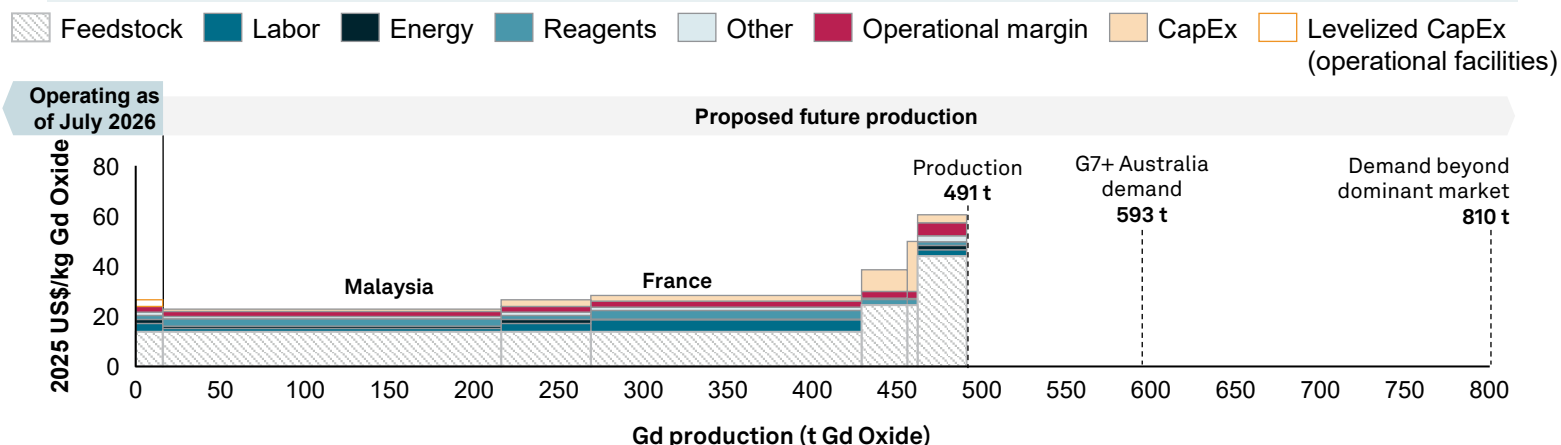
2028 Sm oxide resilient production structural cost curve^{1,2}



2028 Eu oxide resilient production structural cost curve^{1,2}

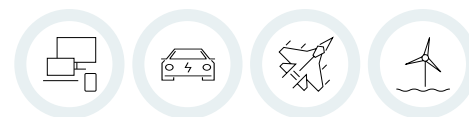


2028 Gd oxide resilient production structural cost curve^{1,2}



1. The analysis excludes assets located in Russia, China, and North Korea, as well as any assets worldwide that are majority-owned by Chinese companies; 2. Utilization rates were estimated using project-announced operating assumptions where available, derived from concentrate grade availability where applicable, and otherwise assumed at 85%, with ramp-up rates of 20% in the first year, 50% in the second year, and 85% thereafter

Sources: S&P Global Analysis for Sm, Eu, Gd supply, demand and costs; USGS (Rare Earths 2026 Commodity Summary)



Structural cost - Findings

- S&P Global CERA estimates structural cost ranges of \$3-4/kg Sm oxide, \$35-42/kg Eu oxide, and \$28-31/kg Gd oxide to support over 85% of resilient supply, equivalent to 873 t, 24 t, and 418 t of production, respectively. These costs are heavily influenced by the allocation of shared separation costs across the rare earth basket. Because costs are allocated based on expected revenue share, the structural costs of Sm, Eu, and Gd are highly sensitive to long-term price assumptions, meaning higher expected prices can materially increase the costs attributed to each oxide.
- Relative to pre-export restriction prices, these structural cost ranges would result in approximately \$0.5-1.4 million, \$100,000-300,000, and \$ 3.1-4.4 million in additional spending in 2028 for Sm, Eu, and Gd, respectively.
- By 2028, an aggregate capital investment for Sm, Eu, and Gd of \$1.3 billion will be required to unlock all announced supply. This supply equates 79%, 46% and 83% of Sm, Eu, and Gd G7 + Australia demand, respectively.
- Feedstock is expected to remain the largest cost component for Sm, Eu, and Gd. By 2028, feedstock costs are expected to range from \$1/kg to over \$4/kg Sm oxide, from \$11/kg to over \$40/kg Eu oxide, and from \$13/kg to over \$44/kg Gd oxide.
- Separation costs are estimated at \$0.6-1/kg Sm oxide, \$4-12/kg Eu oxide, and \$5-13/kg Gd oxide¹. REE extraction involves a trade-off between higher-capital expenditures (CapEx) nitrate circuits and lower-CapEx chloride circuits with higher operating expenditures (OpEx).

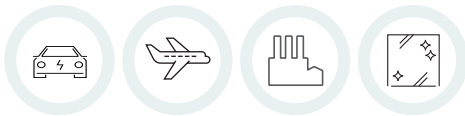


Structural cost - Approach

- Reflects Market Complexity: Built on extensive research and bottom-up modelling, incorporating asset-level data, industry consultation, benchmarking, and expert assumptions to navigate a highly opaque supply chain.
- Targets the Marginal Supplier: The 80th-90th percentile identifies the highest-cost producers. Long-term commodity prices naturally gravitate toward the cost of the last unit needed to meet demand. This percentile filters out extreme outliers while capturing the true marginal cost.
- Incentivizes Supply Resiliency: This analysis establishes a long-term structural benchmark capturing the full asset economics.
- Allocation of cost: Cost allocation is a key consideration in Sm, Eu, and Gd production. Because multiple rare earths are recovered through the same separation process, costs are allocated across the rare earth basket based on the historical sales value of saleable products. Consequently, Sm, Eu, and Gd prices play a major role in determining the costs attributed to each oxide.

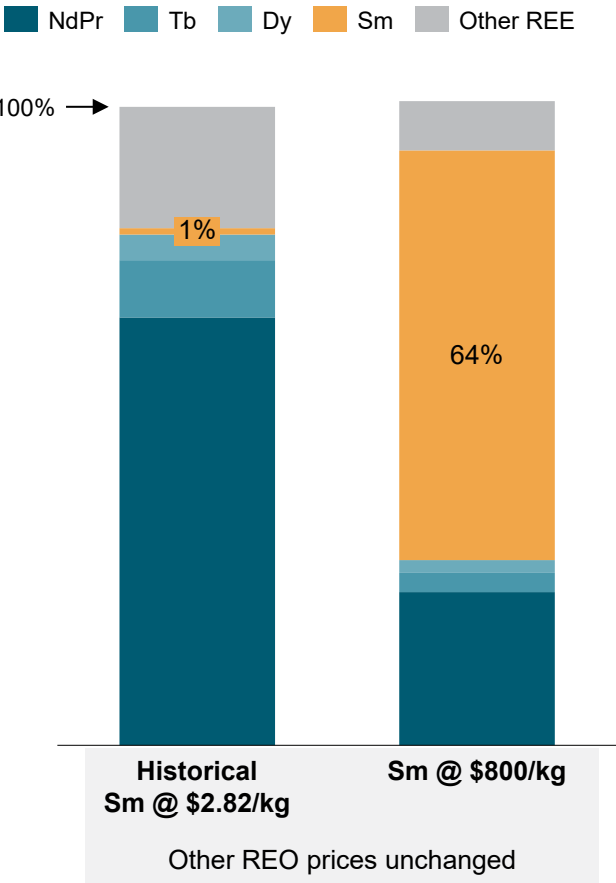
1. Excluding feedstock costs. Separation costs are influenced by recovery rates, but recovery optimization is not a key focus of this analysis.

Sources: S&P Global Analysis for Dy and Tb supply, demand and costs; USGS (Rare Earths 2026 Commodity Summary)



Cost allocation sensitivity

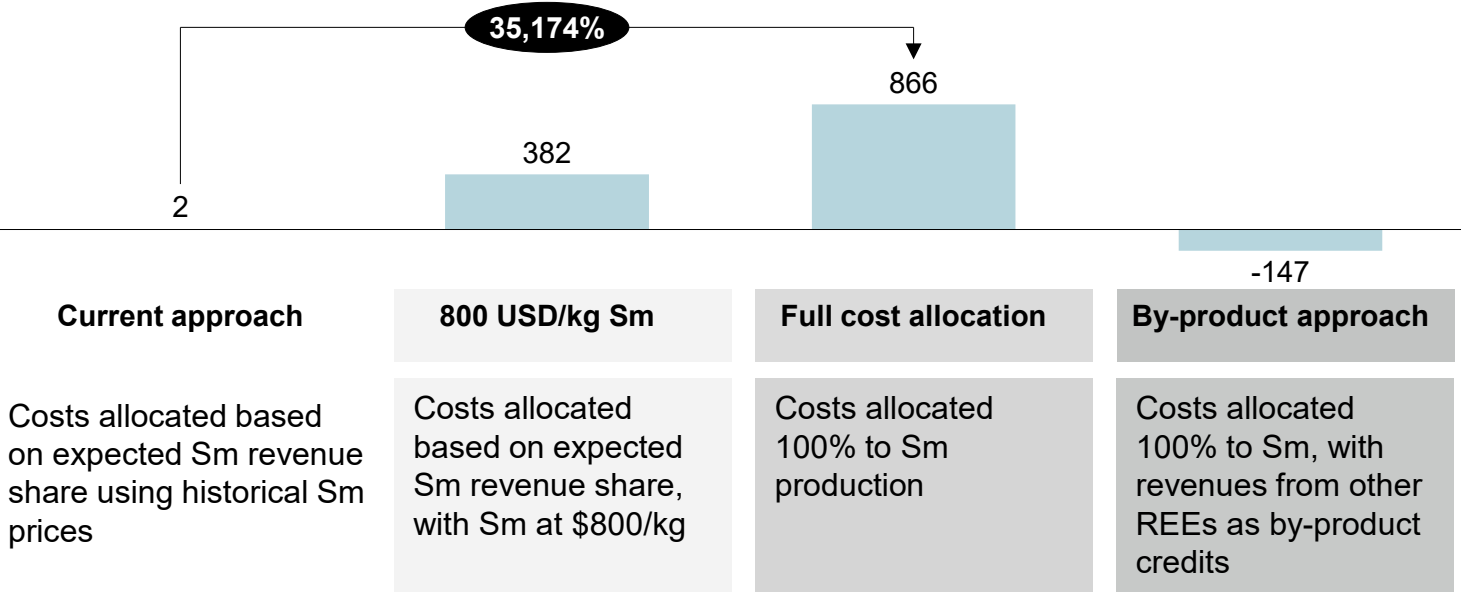
REO revenue share – high grade Sm feedstock



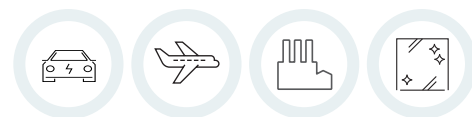
- Given the magnitude of recent changes in Sm prices, the role of Sm in refinery economics can differ significantly from the past.
- For a high grade Sm feedstock, at historical REE prices, Sm oxide (~\$3/kg) accounted for less than 1% of refinery revenue. As a result, Sm has not been a primary driver of refinery economics or investment decisions. At \$800/kg Sm¹ (with other REO prices unchanged), Sm's revenue share could increase to ~64%, shifting it from a by-product to the primary value driver.
- As a result, the allocation of costs to Sm relative to other separated REEs becomes sensitive to the underlying price assumptions.
- Cost allocation to Sm may also increase where offtake agreements place a premium on secure Sm supply, particularly for defense applications.
- Similar dynamics could emerge for Eu and Gd. If prices rise significantly, their contribution to refinery revenues could increase materially, altering project economics and the allocation of costs across separated REEs.

Sm oxide production cost sensitivities

USD/kg Sm



¹ Based on the Platts CIF North America samarium oxide assessment, August 2026.



Challenge of cost components and methodological approach

Feedstock specification is an important determinant of downstream processing costs. Differences in total REE grade, individual REE concentration, mineralogy, and impurity content influence reagent consumption, power requirements, recovery rates, and process complexity. As a result, two feedstocks with similar Sm, Eu and Gd output can have materially different separation costs and overall project economics.

Mining and Processing costs



Feedstocks: Feedstock costs are based on each facility's sourcing strategy, using associated mining costs for vertically integrated facilities and weighted average feedstock costs for non-vertically integrated facilities based on the feedstock type. Overall asset level mining and processing costs are estimated following a similar asset level approach to the separation of costs allocated across NdPr, Dy, Tb, Sm, Eu, Gd and Y according to expected revenue share.



Labor¹: Labor costs are estimated using labor cost factors per metric ton of feedstock processed, differentiated by feedstock type and separation process. Labor costs are scaled based on wage rates by country.



Separation OpEx

Energy¹: Includes fuel, power and utility costs, estimated using energy intensity factors differentiated by feedstock type and separation process. Energy demand is assumed to comprise 80% natural gas and 20% electricity, with costs based on facility throughput and adjusted for country-level natural gas prices and wholesale electricity tariffs.



Reagents¹: Reagent costs are estimated using chemical consumption rates per metric ton of production and corresponding regional prices. Estimates are based on a combination of reagent-specific consumption data and reported overall reagent costs.



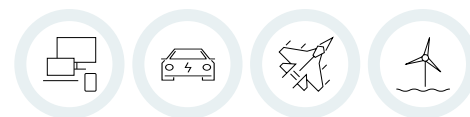
Operational margin: An operational margin is applied to represent the facility-level profit margin, ongoing sustaining capital requirements, and return on investment. The margin was assumed to be 10% of total facility costs, excluding initial and sustaining CapEx.



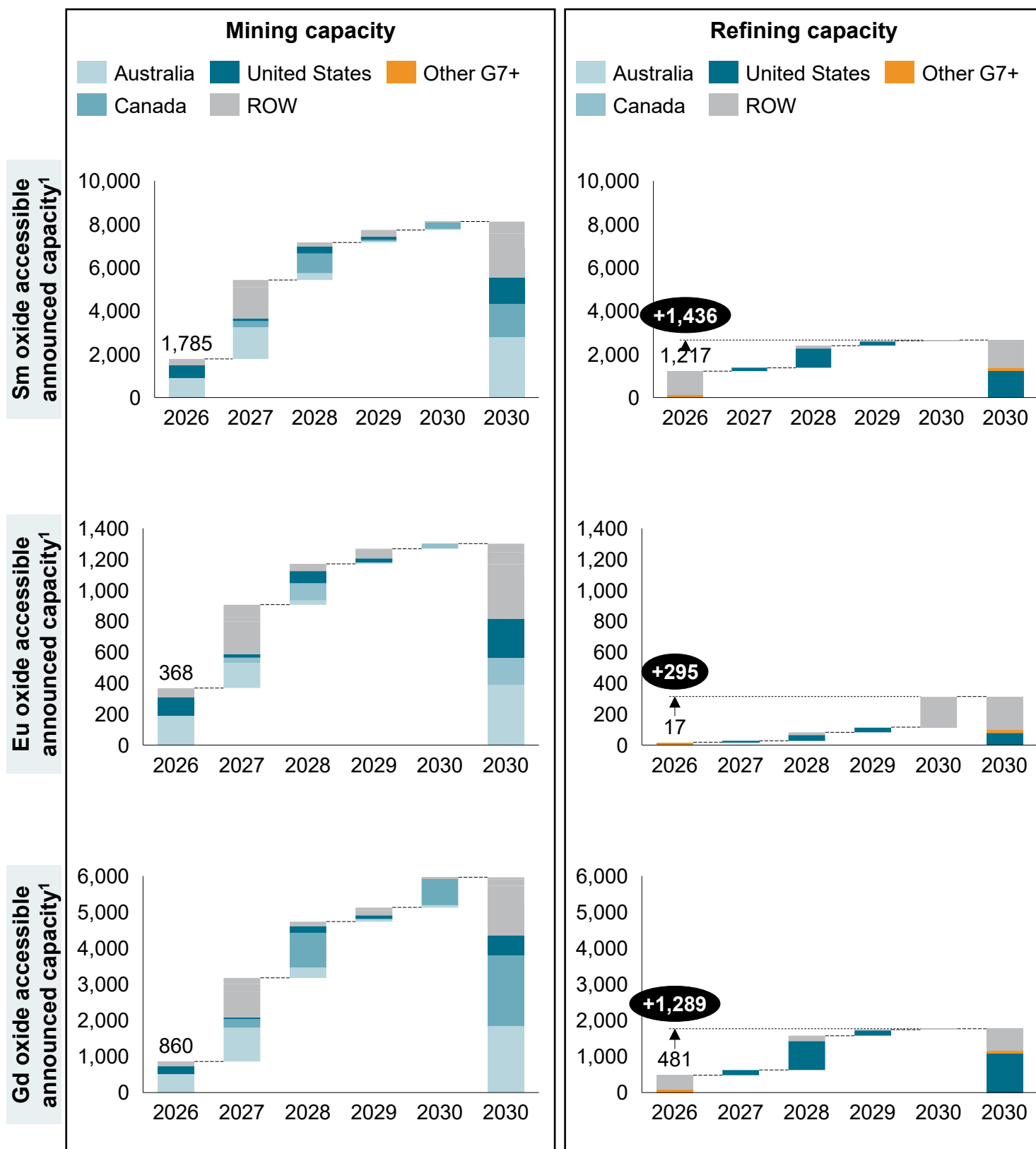
Separation CapEx

Capital expenditure: Includes levelized initial CapEx, allocated to each facility and recovered over a 20-year project life using a 7% discount rate. Sustaining CapEx represents ongoing investments required to maintain operations and productive capacity, estimated as a percentage of initial CapEx. Capital costs are allocated across NdPr, Dy, Tb, Sm, Eu, Gd, Y and Ho based on their estimated revenue share.

1. Operational costs (Labor, Energy, Reagents) are allocated across all rare earth products announced by each facility, assuming the facility is able to separate and commercialize its full rare earth product basket.



The supply chart represents potential risked supply pipeline based on company announcements for separated Sm, Eu, and Gd oxide



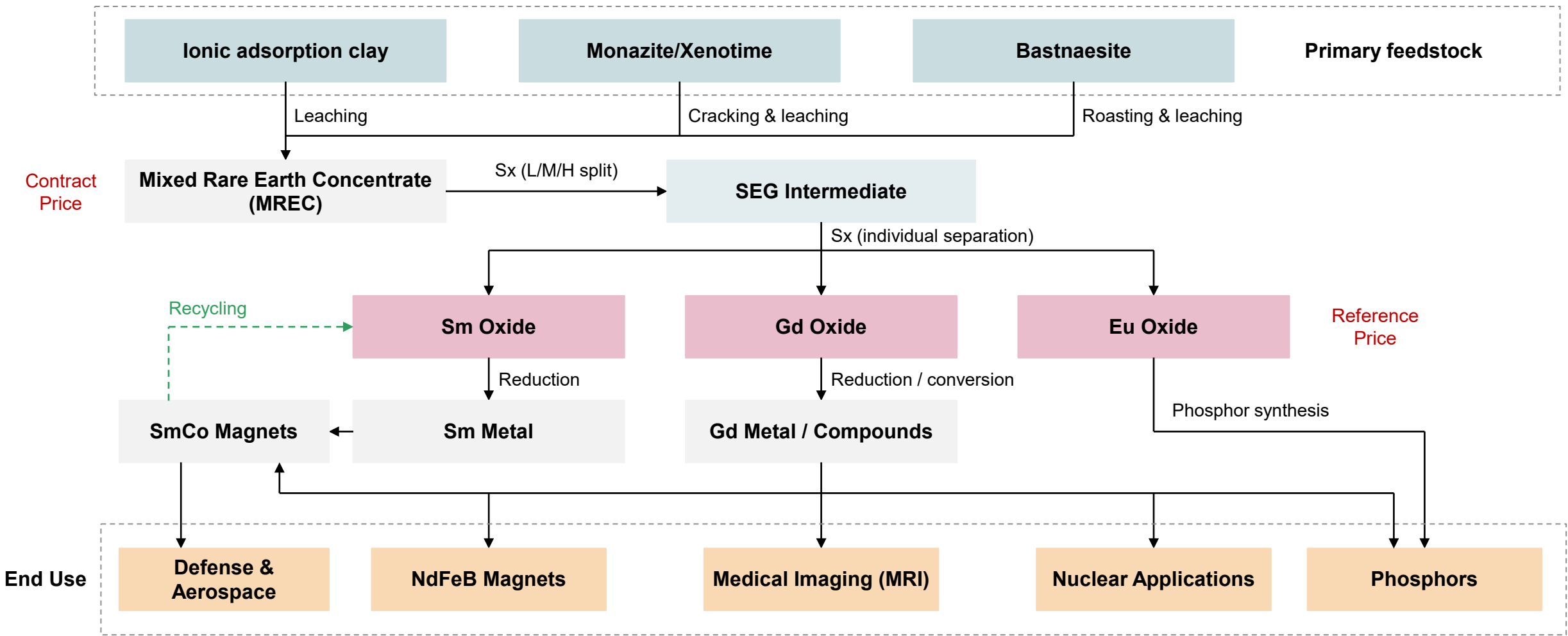
1. The analysis excludes assets located in Russia, China, and North Korea, as well as any assets worldwide that are majority-owned by Chinese companies (Myanmar and Laos). The capacity excludes potential supply from separating SEG concentrate; 2. ROW includes HREE mining and refining capacity in countries not shown separately, including Brazil, Namibia, South Africa, Sweden, Norway, among others.

Sources: S&P Global Analysis

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SEG Market Report | Samarium, Europium, Gadolinium

SEG value chain



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