

A close-up photograph of several large, clear, and highly reflective germanium crystals. The crystals exhibit a complex, faceted structure with many sharp edges and flat surfaces that catch the light, creating bright highlights and deep shadows. They are set against a dark, textured background that appears to be more crystals or a mineral matrix.

S&P Global Energy

Germanium Market Report

Germanium (Ge)

October 2026

Preamble

This draft **Germanium Market Report** aims to increase transparency within the germanium supply chain, helping public and private stakeholders make more informed investment decisions across the commodity lifecycle. It briefly outlines current supply chain bottlenecks, resiliency issues, and the market signals needed to support a more robust and diverse supply base.

S&P Global conducted a bottom-up, asset-level analysis of production costs for germanium extraction refining. These production cost curves are based off the germanium refining production processes, providing an independent view of supply economics and identifying the marginal supplier in a structurally tight market. The analysis focuses on a resilient supply base outside dominant market positions and restricted supply sources.

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 the opaque mineral value chain.

The market values in this report represent a fundamentals-based assessment of the cost and the break-even range required for germanium 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.

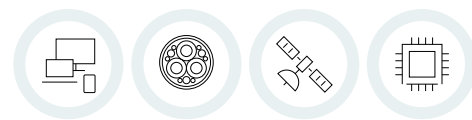
These values are different to the spot market price assessments published by Platts, part of S&P Global Energy ([link](#)).

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 input¹ from market participants to support the ongoing refinement of future editions.

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1. S&P Global would like to acknowledge and thank Rovjok for their feedback and contribution.



Key Takeaways

- S&P Global estimates that the germanium refineries require a structural cost¹ of between \$2,100-3,000/kg Ge¹ in 2028 to sustain the current or announced capacity pipeline, resulting in approximately \$30-78 million in additional spending in 2028.
- Germanium demand is expected to grow 3.3% per year through 2030, driven by growing infrared and thermal imaging technologies use in defense, industrial, and automotive applications.
- New capacity additions in resilient markets are expected to add 103 metric tons (t) of Ge, increasing total resilient supply² refining capacity to 176 t Ge.
- Under the announced project pipeline, a total of six resilient supply refineries could be operating by 2030. However, capacity would still cover only ~73% of demand beyond dominant market³.

Introduction

Germanium is a specialty metal valued for its ability to transmit infrared light and control the movement of light and electrical signals. Its infrared transparency makes it important for thermal-imaging lenses, night-vision systems and targeting equipment, while germanium dioxide adjusts the refractive index of optical-fiber cores to enable low-loss data transmission. In electronics, Ge's electron mobility is three times that of silicon, supporting high-frequency SiGe chips, while germanium substrates are used in high-efficiency solar cells for satellites and other space systems.

From a supply perspective, germanium is not currently mined directly and is instead primarily recovered from germanium-bearing residues and side streams generated during zinc processing, with additional production from coal-related residues and recycled materials. Because it exists in trace concentrations, its economics are dwarfed by zinc operations, offering little commercial incentive to allocate capital recovery circuits rather than maximizing zinc output. Commercial markets are broadly divided between germanium dioxide and high-purity germanium metal, which is refined to electronic and optical grades.

More than 90% of germanium refining capacity is concentrated in China, while the manufacture of germanium-based components is more geographically distributed. China introduced export licensing in August 2023 and banned exports to the United States in December 2024 and to Japan in January 2026. Although the ban was suspended through November 2026, licensing requirements and restrictions on military uses remain, prompting new recovery, refining, and stockpiling initiatives outside China to reduce supply-chain exposure.

Germanium's Properties

Infrared transmission:
~14 μm

Wider than silicon (~7 μm) or sapphire (~5 μm)

Light refraction index:
~4.0 (light travels 4x slower)

Highest of common lens materials – vs. silicon ~3.4

Electron mobility:
~3,900 $\text{cm}^2/\text{V}\cdot\text{s}$

Electrons move ~3x faster than in silicon (~1,500 $\text{cm}^2/\text{V}\cdot\text{s}$)

1. Assumes costs are shared with gallium production, reducing standalone capital and operating requirements; 2. Resilient supply excludes China, Russia, and North Korea as suppliers; 3. Demand beyond dominant market comprises global demand excluding China.
Sources: S&P Global, USGS



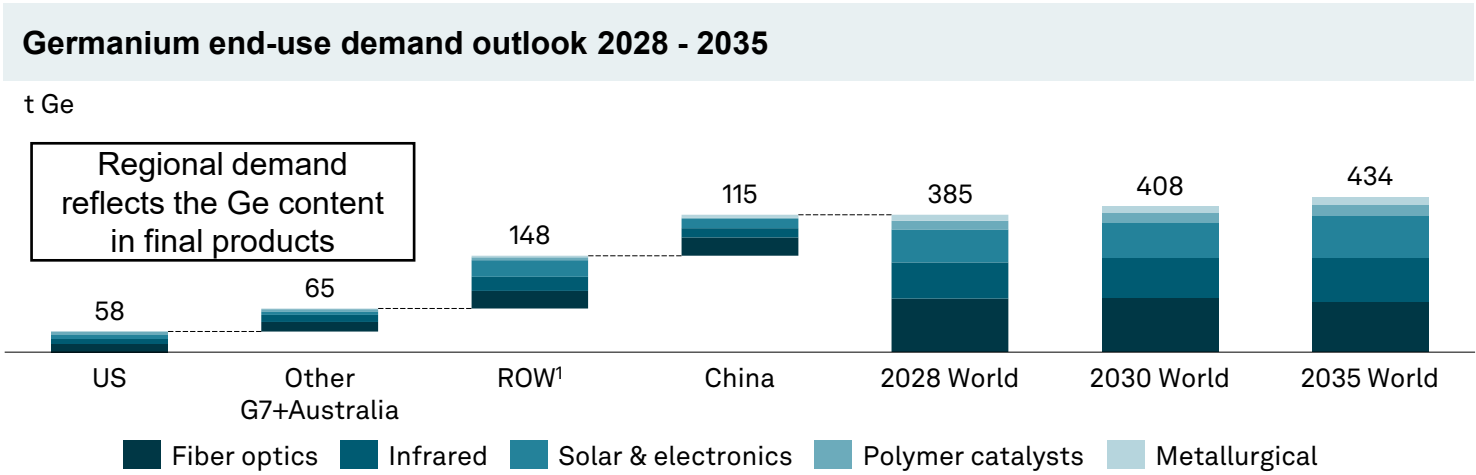
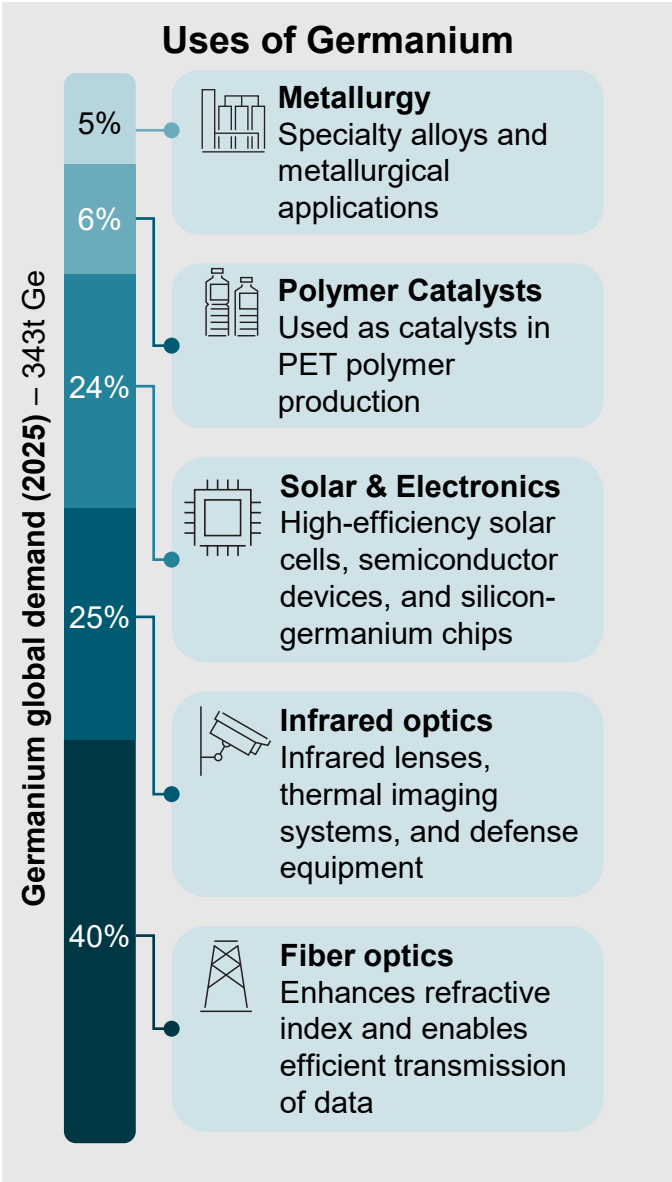
Germanium demand

Demand for germanium is primarily driven by fiber-optic communications, infrared optics, and satellite-grade solar cells, although end-use demand spans a broader range of telecommunications, semiconductor, defense, industrial, and aerospace applications. Germanium is consumed in forms including germanium dioxide (GeO₂), germanium metal, wafers, and silicon-germanium (SiGe) materials used across these technologies.

Germanium is typically used in very small quantities across its end-use applications, making consumption difficult to track through traditional trade and production statistics. As a result, official and accurate estimates of global demand remain uncertain. Nevertheless, our analysis estimates global germanium demand at approximately 343 t Ge in 2025.

Fiber optics remain the largest germanium end-use sector, accounting for 142 t Ge of demand in 2026 and peaking at 153 t Ge in 2030. China and G7 + Australia each represent ~30% of demand through 2030. Infrared optics drive demand growth, supported by defense and advanced commercial applications, with global consumption increasing 34% through 2035 with growth led by China (+43%). China remains the largest germanium end-use market, while infrared accounts for most incremental demand growth.

Substitution remains difficult in infrared optics and fiber optic applications, where germanium's optical and refractive properties are hard to replicate.





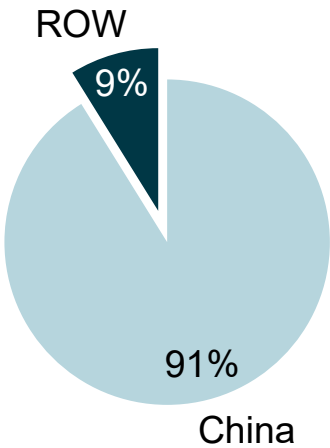
Germanium supply

Germanium supply is largely recovered as a by-product of zinc processing, with most announced projects relying on existing smelting assets and recovery from process residues and tailings. Additional potential supply sources include primary germanium mining (e.g., Apex Mine in the US) and recovery from coal ash and gasification residues. Coal-derived germanium is concentrated in China, with no announced projects in resilient markets. This reflects the limited availability of germanium-rich coal deposits elsewhere, as well as the declining role of coal mining and coal-fired power generation in many jurisdictions.

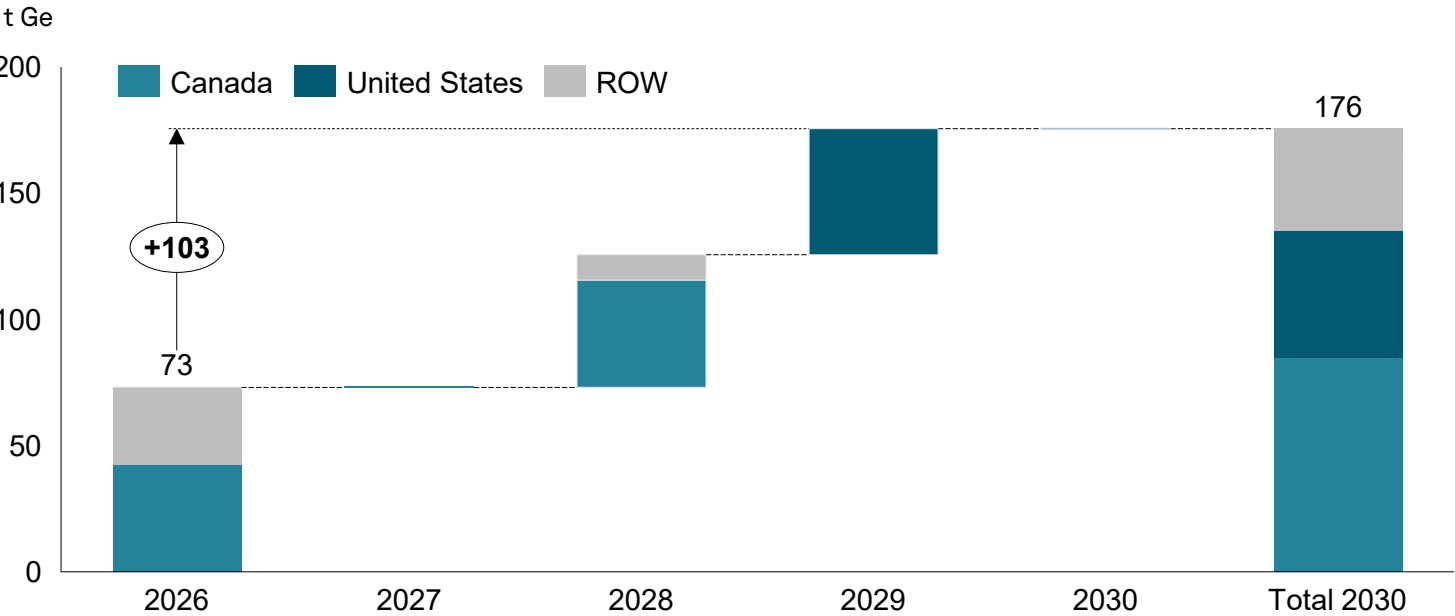
China represents 91% of primary germanium production, while the remaining 9% originates from facilities in Belgium and Canada¹. Primary germanium capacity outside China is ~73 t Ge, with a further 103 t Ge potentially developing in Canada, the United States and South Korea. Current secondary germanium supply is ~39 t Ge.

Supply and capacity figures are reported on a contained-germanium basis. Cost estimates are normalized to contained Ge and modeled through production of GeO₂, although facility output may be GeO₂, GeCl₄ or Ge metal.

Primary germanium supply² (2025)

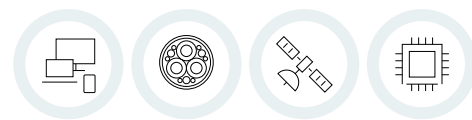


Germanium production potential (primary) resilient supply capacity³



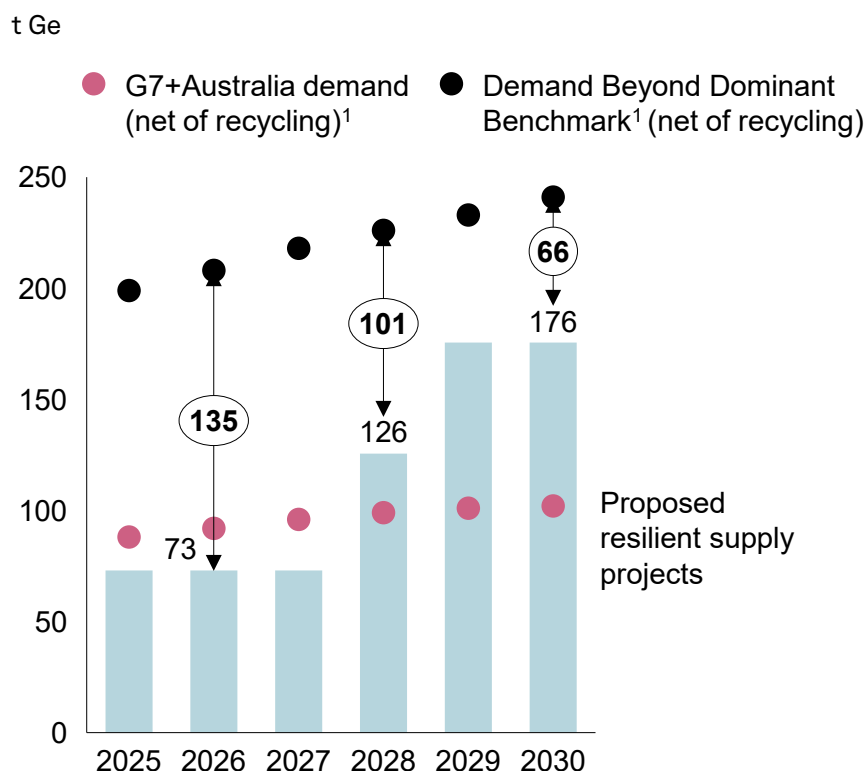
The supply chart represents potential risked supply pipeline based on company announcements

1. In addition, the Iijima refinery in Japan is currently operating, although production is estimated at less than 1 t Ge; 2. Based on data from : *Quantifying Potential Effects of China's Gallium and Germanium Export Restrictions on the U.S. Economy* report (USGS, 2024); 3. Resilient supply excludes China, Russia, and North Korea as suppliers
Sources: S&P Global



Supply-demand balance

Supply-demand balance outside of China and Russia



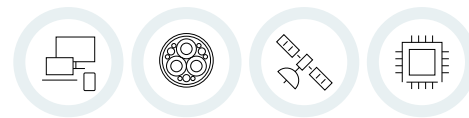
- A supply gap of approximately 135 t Ge is expected in 2026, with available resilient supply totaling only 73 t Ge.
- In 2028, an additional 53 t Ge of planned new capacity would still result in a gap of ~101 t Ge due to demand growth, although G7 + Australia demand would be met.
- By 2030, total capacity is set to reach 176 t Ge, far surpassing G7+Australia demand but leaving a 66 t Ge supply deficit relative to the total demand beyond the dominant market.



Recent market events

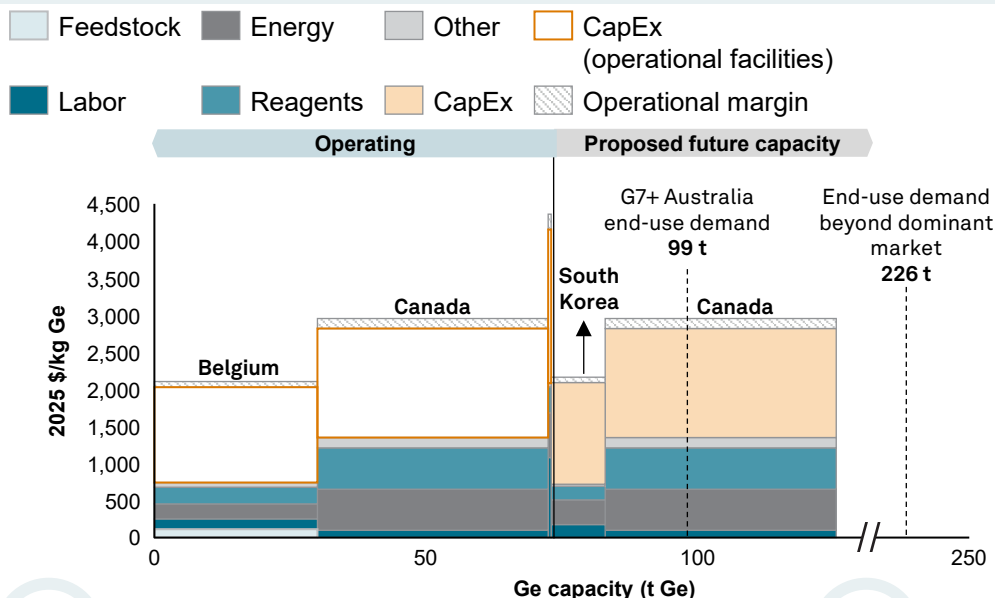
- The Canadian government signed an investment agreement establishing a commercial framework for an equity-like investment by Canada Growth Fund (CGF) of up to C\$400 million as part of Teck's broader potential investment of up to C\$850 million to expand critical minerals production capacity at Trail [Platts, July 2026].
- Teck Resources is working with Titan Mining Corp. to evaluate germanium content at the Empire State Mines in New York, while Bunker Hill in Idaho is scheduled to begin commercial production by end-2026, with initial concentrate bound for Teck's Trail smelter in Canada [Platts, July 2026].
- SUEK, Russia's largest thermal coal producer, reached 50 kg/month of germanium raw material output extracted from coal combustion ash, with plans to begin producing germanium concentrate in 2026 [Platts, June 2026].
- Korea Zinc launched Crucible Zinc Inc. and completed the acquisition of Nyrstar's Clarksville, Tennessee smelter to build a \$7.43 billion integrated critical metals facility. The site holds ~620,000 t of smelting by-products containing germanium, gallium, and indium [Platts, April 2026].

1. Demand beyond dominant market comprises global demand excluding China.
Sources: S&P Global, Project Blue for recycling figures



Germanium structural cost

2028 Germanium primary production structural cost curve



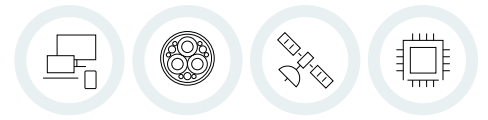
Structural Cost: Represents the full cost required for an asset to achieve its target return on investment, assuming projects are developed in line with announced timelines and operate at capacity. This cost considers an unrisks projection subject to normal industry attrition and delays

Structural cost - Findings

- S&P Global CERA estimates that a structural cost range of **\$2,100/kg - \$3,000/kg** would support the entire resilient supply pipeline of 126 t Ge by 2028
- Relative to pre-export restriction prices of ~\$1,535/kg, these structural cost ranges would result in approximately \$30-78 million in additional spending in 2028.
- By 2028, an aggregate capital investment of \$547 million will be required to unlock all announced supply. This supply would exceed G7 demand. Excluding capital expenditures (CapEx), a cost range between **\$795/kg to \$1,500/kg** would sustain project operations once commissioned.
- Zinc projects often also recover gallium, allowing infrastructure, labor, utilities, and select operating costs to be shared across both metals.
- Production costs are highly sensitive to feedstock quality. Lower ore grades require higher feedstock throughput to sustain output, increasing variable costs. Differences in concentrate, residue, and secondary-feed grades are therefore a key driver of facility cost competitiveness.

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 rather than a short-term forecast, capturing full asset economics.
- Feedstock costs are only considered for assets purchasing third-party feedstock. Generally, germanium is recovered from side streams generated during zinc processing.



Challenge of cost components and methodological approach

Refining



Labor: Labor costs are estimated by combining the number of full-time equivalent employees (FTEs), regional processing/refining wage rates, and a regional multiplier to account for additional mining and refining labor costs. FTE requirements are estimated using an S-curve relationship between plant capacity and workforce size, calibrated with available industry data.



Energy: Power and utility costs are estimated based on the electricity consumption required per metric ton of production and the local wholesale electricity price.



Reagents: 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. Reagents used exclusively in germanium refining were fully allocated to germanium.



Operational margin: A 10% operational margin is applied to facility OPEX costs to represent facility-level profitability. This adjustment shifts the curve from a cost basis to a price-like basis.



Capital expenditure: Includes levelized initial CapEx, allocated to each facility and recovered over a 20-year project life using a 7% discount rate to reflect the time value of money, as well as sustaining CapEx representing ongoing investments required to maintain operations and productive capacity, estimated as 2% of initial CapEx.



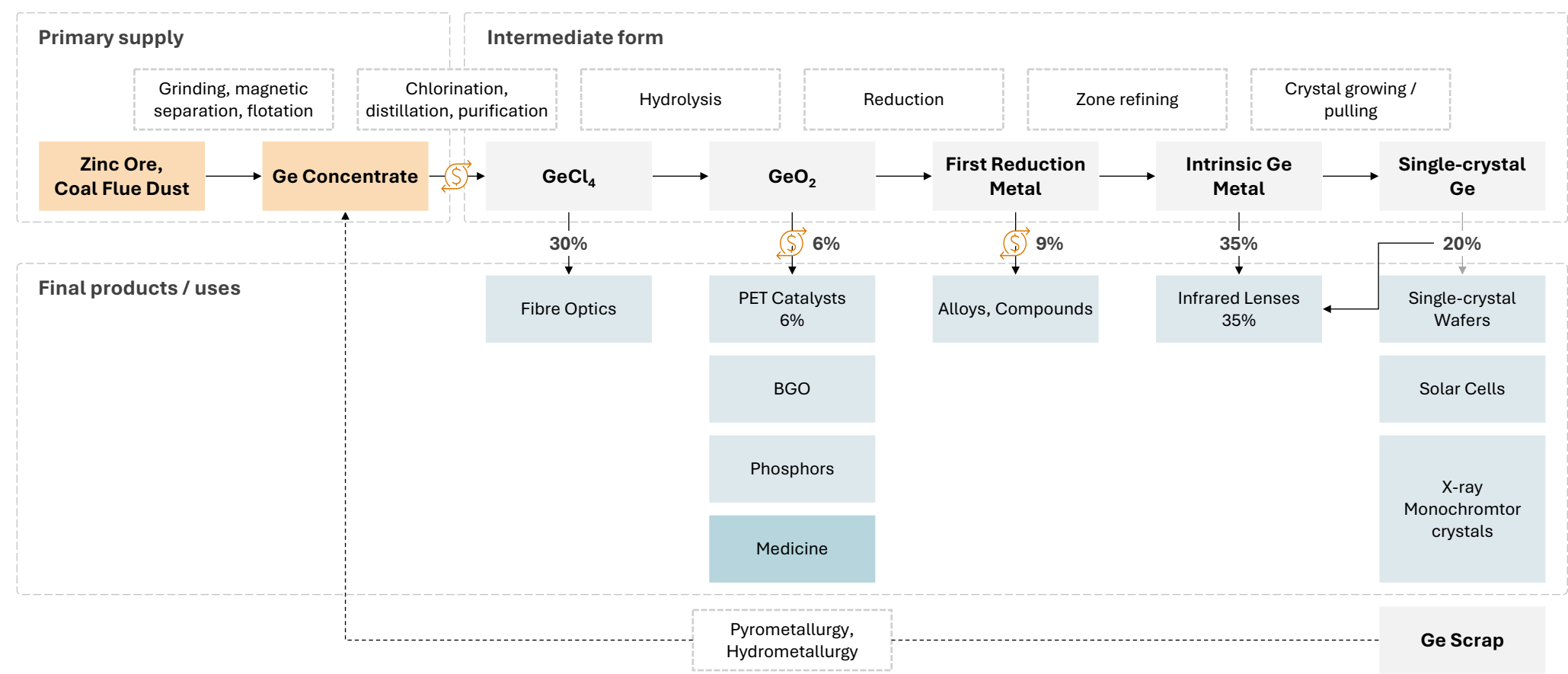
Feedstock: Feedstock costs are only considered for assets purchasing third-party feedstock. Generally, germanium is recovered from side streams generated during zinc processing

All cost components are estimated at the facility level and converted to a unit cost based on annual capacity.

Co-product cost allocation: Shared costs are allocated based on gallium and germanium share of expected revenue, while costs attributable to mineral-specific processes were assigned entirely to the corresponding mineral. Expected revenue was estimated as production volume multiplied by expected prices of gallium and germanium. Values are preliminary and will be refined through further S&P Global analysis, data review, industry consultation and stakeholder review.

Ge Market Report | October 2026

Ge value chain



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