RBC Thought Leadership

Explained

Critical Minerals Processing

The West's refining challenge and the technologies closing the gap

The West has ceded critical minerals processing to China–and rebuilding that capacity in a way that is environmentally permittable, economically viable, and scalable within Western regulatory frameworks is a defining industrial challenge of the decade.

Why Processing Went to China

China controls 70% of the global refining market share for 19 of the world's 20 most critical minerals; across minerals such as rare-earth elements that figure is north of 90%. This dominance is the compounding effect of three structural forces, each reinforcing the other over time.

Economics. China's historically low labour costs, energy subsidies, and state-backed industrial policy built a cost structure that undercut Western processors at prevailing commodity prices.

Environment. Conventional rare earth processing relies on sulphuric acid baking, multi-stage leaching, and solvent extraction, generating toxic waste streams and radioactive tailings. According to a Harvard analysis, for every tonne of rare earth output, conventional processing produces roughly 2,000 tonnes of toxic waste. Western jurisdictions internalize those costs through permitting, environmental liability, and community opposition.

Industrial ecosystem. As China's processing capacity scaled, it drew in engineering talent, downstream manufacturers, and end-use demand—each reinforcing the next. As Western processing retreated over the last 40 years, financial markets stopped funding, institutions stopped training, and downstream manufacturers defaulted to Chinese supply. China accumulated the opposite—four decades of process knowledge, engineering expertise, and refining IP that enforces a barrier to Western re-entry.

The Environmental Opportunity and Technology Response

Rebuilding Western processing capacity by replicating China's model runs into the same barriers that caused offshoring. Arguably it's now compounded by China's October 2025 export controls on processing equipment and technology. A more tractable path confronts the environmental liabilities of conventional methods directly—and in doing so, also improves the economics.

Grant and procurement decisions offer a reasonable proxy for which processing approaches have cleared basic viability thresholds. The U.S. Department of War, Department of Energy, and the Government of Canada have directed meaningful capital toward next-generation critical minerals processing since 2022.

Waste and tailings. New processing approaches—including flash heating and modular ion-exchange systems—substantially reduce or eliminate waste streams, making projects permittable where conventional processing would not be.

Canadian firm Ucore Rare Metals is a case in point. Its RapidSX platform is a column-based solvent extraction system for rare earth separation that runs approximately three times faster than conventional mixer-settler systems, with a smaller physical footprint and no Chinese equipment or technology. The U.S. Department of Defense (DoD) awarded US$4 million for Ucore's Kingston, Ontario, demonstration facility, followed by US$18 million toward its Louisiana Strategic Metals Complex. The Government of Canada committed $36 million at the G7 resource ministers meeting in October 2025 to support refining of samarium and gadolinium.

Emissions. Decarbonizing processing is mainly a question of energy source: replacing fossil-fuel-fired kilns and furnaces with electrically powered alternatives—particularly hydro or other clean sources—solves the emissions problem and improves economics given falling clean electricity costs. Most global critical mineral refining runs on coal-heavy Chinese grids. Processing on hydroelectric power, as Quebec offers, materially changes the emissions profile of the same output.

Australia-based Metallium Resources Inc. is working on a solution to transform metal recovery and recycling waste through flash joule heating—millisecond electrical pulses to heat material above 3,000 degrees Celsius, extracting metals selectively without acid or water. The U.S. DoW provided an initial gallium-focused grant and selected the technology as a processing step in a DoW-funded red mud recovery project in Louisiana. Metallium's Texas demonstration plant has been commissioned, with feedstock supply secured through a binding agreement with commodity firm Glencore plc.

Recycling. The IEA finds recycled energy transition minerals such as nickel, cobalt, and lithium produce on average 80% fewer greenhouse gas emissions than primary mined material. Recycling rates for rare-earth elements and lithium remain below 5% globally, yet feedstock is accumulating fast: spent EV batteries, end-of-life wind turbine magnets, and electronic waste from AI infrastructure all carry recoverable critical metal content.

The EU has institutionalized recycling demand through binding regulation. Under EU Battery Regulation 2023/1542, manufacturers face minimum recycled content requirements. These are enforceable compliance thresholds—not targets. They create a structural demand signal for recovered materials that current processing infrastructure cannot meet.

ReElement Technologies is aiming to turn scrap into mining stock. A subsidiary of American Resources Corp, ReElement runs a modular ion-exchange and solvent-based refining platform processing rare earth magnet scrap and lithium-ion battery black mass into high-purity separated products. The platform accepts multiple feedstock types without Chinese primary concentrates. ReElement has received DoD and Department of Energy funding as part of the U.S.'s effort to establish domestic rare earth and battery metal refining capacity.

Challenging China's rare-earth refining dominance will take time, but the funding of experimental technologies, backed by policy focus and support, suggests that the transition is finally underway.

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