The Dual-Edged Sword of Rare Earth Mining: Environmental Impacts vs. Energy Needs

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The modern technology that enables the digital age and our transition to renewable energy comes at a steep environmental cost from the mining of rare earth elements (REEs), which make these innovations possible.[1] REEs like neodymium, dysprosium, and lanthanum are critical components of electronics, electric vehicles, wind turbines, solar panels, and energy storage batteries.[2] As global demand for these technologies soars, the environmental impacts of REE mining have become a critical issue we can no longer ignore.

REE mining is an enormously destructive process for the natural landscape. Open-pit mines tunnel vast craters through pristine ecosystems, generating huge volumes of hazardous radioactive waste that can contaminate soil and groundwater.[3] In China's Inner Mongolia, decades of REE mining have created vast toxic wastelands once blanketed in grasslands and sand, now poisoned by heavy metal and radiation exposure.[4] Processing REEs also consumes staggering amounts of water, electricity, toxic chemicals like sulfuric acid and ammonia, and produces even more hazardous byproducts like radioactive thorium waste residues.[5] A single metric ton of REEs generates 2,000 tons of radioactive waste residues and 200m3 of acidic water.[6] This toxic cocktail has already contaminated water supplies in areas like Malaysia's Bukit Merah, leaving locals suffering from birth defects, deadly cancers, and lead poisoning.[7]

Paradoxically, these environmentally devastating practices underpin our transition to a sustainable energy future. REEs form critical components of technologies like electric vehicles, wind turbines, solar panels, rechargeable batteries, and electronics that enable reduced emissions and increased energy efficiency.[8] Wind turbines require hefty doses of neodymium to create the super-strong magnets used for electricity generation.[9] Electric vehicles have large amounts of REEs as REEs compose portions of components like powertrain magnets and battery alloys.[10] As the world strives to decarbonize by rapidly scaling up solar, wind, energy storage, and transitioning transportation to electric vehicles, the demand for these REE-dependent technologies will skyrocket.[11] According to some projections, the global demand for neodymium and dysprosium could increase by 8 times by 2030.[12] This surging demand will require greatly expanding environmentally devastating REE mining unless alternatives are developed.

Faced with this dilemma, the path forward entails developing both recycling and alternative technologies to reduce REE dependence, coupled with stronger environmental

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[1] Nick Ogasa, *How rare earth elements' hidden properties make modern technology possible*, SCIENCENEWS (Jan. 16, 2023). https://www.sciencenews.org/article/rare-earth-elements-properties-technology.
[2] *Id.*
[3] Jaya Nayar, *Not So "Green" Technology: The Complicated Legacy of Rare Earth Mining*, HARVARD INTERNATIONAL REVIEW (Aug 12, 2021). https://hir.harvard.edu/not-so-green-technology-the-complicated-legacy-of-rare-earth-mining/.
[4] *Id.*
[5] *Id.*
[6] Lisa Depraiter, *The role and challenges of Rare Earths in the Energy Transition*, RESOURCES POLICY (Oct. 2023). https://shs.hal.science/halshs-04199796v1/file/REE_in_Energy_Transition_DG.pdf.
[7] *Id.*
[8] *Id.*
[9] *Id.*
[10] *Id.*
[11] *Id.*
[12] *Id.*

regulations for responsible mining practices.[13] Recycling REEs from discarded electronics, wind turbine components, and batteries could reduce some of the demand for new mining, but this remains challenging due to the complex processes required.[14] Researchers are also exploring alternative magnet technologies using more abundant materials like Iron-Nitride to reduce reliance on REEs.[15] However, these tend to fall short of the power and performance of REE magnets. On the regulation side, much remains to be done as REE mining has been essentially unregulated for decades while China supplied over 85% of global REE production and dominated the market.[16] However, growing concerns over this monopoly and the environmental toll of REE mining are driving nations to establish stricter regulations and standards. Within the U.S., which embarked on renewing domestic REE production, the process is far more regulated under statutes like the Clean Air Act, Clean Water Act, and other federal and state laws governing mining, hazardous materials, and environmental protection. But controversy remains over how stringently these laws will constrain practices compared to existing operations.

The molten salt extraction process developed by the U.S. company EnergyX offers one example of a more sustainable REE extraction method that massively reduces waste runoff and radiation exposure compared to conventional acid-based extraction.[17] However, even this improved method consumes significant water and energy resources. The newly opened Mountain Pass rare earth mine in California is reemerging as a U.S. domestic production source but has already faced challenges living up to sustainability ambitions.[18] Its previous operators went bankrupt amidst hazardous waste violations and the company currently ships materials to China for processing due to the higher costs of processing domestically.[19] Expanded domestic processing facilities would be required to establish a truly self-sustaining and responsibly regulated American REE production supply chain.

Ultimately, while REEs catalyze our transition to sustainable energy technologies, the paradoxically devastating environmental impacts of extracting them are an immense challenge we must confront head-on. Developing recycling infrastructure, alternative material technologies, and stringent yet pragmatic regulations for responsible mining practices that balance economic growth and environmental protection will be crucial for resolving this issue. The pathway will not be simple, but failure is not an option as we strive for a greener future powered by these elements. Ultimately, environmentally sustainable mining and processing of rare earth elements is possible, however it will take more investment, research and development before that reality occurs.

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[13] Erin Wayman, Recycling rare earth elements is hard. Science is trying to make it easier, SCIENCENEWS (Jan 20, 2023). https://www.sciencenews.org/article/recycling-rare-earth-elements-hard-new-methods.
[14] Id.
[15] Id.
[16] Depraiter supra note 6.
[17] Ernest Scheyder, Lithium startup EnergyX gets $450 mln investment tied to IPO plans, REUTERS (July 22, 2022). https://www.reuters.com/markets/us/lithium-startup-energyx-gets-450-mln-investment-tied-ipo-plans-2022-07-22/.
[18] Maddie Stone, A once-shuttered California mine is trying to transform the rare-earth industry, Grist (Jun 15, 2023). https://grist.org/energy/a-once-shuttered-california-mine-is-trying-to-transform-the-rare-earth-industry/.
[19] Id.