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Title: **Rare Earths: Critical Material for Energy Transition**

ABSTRACT

The massive deployment of a wide range of clean energy technologies, increasing penetration of renewable energy into the energy supply mix and improvements in energy storage have brought about a significant energy transition and gained rapid momentum. Today, renewable energy has become a powerful and cost-effective source of energy. Energy transition is a transformation of the global energy sector from fossil-based systems of energy production and consumption to renewable energy sources and is made possible by technological advancements and a societal push towards sustainability.

REEs have become a material of focus for the energy transition. The deployment of energy technologies such as wind turbines and electric vehicles (EVs) have raised the demand for these key materials. Reducing material intensity and encouraging material substitution via technology innovation can also play major roles in alleviating strains on supply, while also reducing costs. With the pace of energy transitions, supply security of rare earth elements is gaining prominence.

Rare Earth elements have played critical role in enhancing the performance of core/functional material. They're vital to catalytic converters, hybrid cars and wind turbines, as well as energy-efficient fluorescent lamps. Permanent magnets are another big role for rare earths. Their light weight and high magnetic strength have made it possible to miniaturize a wide range of electronic parts, including many used in EVs, home appliances, audio/video equipment, computers, military gear to name a few. They also find application in polishing, rechargeable batteries, glass, ceramics, phosphors, pigments, etc.

The criticality of rare earth minerals stems from their importance in developing green technologies. Neodymium and praseodymium (LREEs) are key critical materials in the manufacturing of neodymium-iron-boron (NdFeB) magnets. NdFeB magnets have the highest magnetic strength (energy product) among commercially available magnets and enable high energy density and high energy efficiency in energy technologies.

Dysprosium and terbium (HREEs) are key critical materials often added to the NdFeB alloy to increase the operating temperature of the magnets. Lanthanum and cerium are used in batteries for hybrid and electric vehicles, while terbium and europium are used in lighting and display technologies.

Monazite being the principal source of rare earths in India is known to be radioactive in nature. Less than 0.1% by weight of Monazite is present in beach sand. The mining and extraction processes are quite complex in nature due to assemblage of other minerals like ilmenite, rutile, zircon and sillimanite. Extraction is subjected to grain size, geology, dispersion of deposit and concentration required to have a meaningful deliverables. Mineral separation followed by a specialized chemical process is adopted to produce purified RE compounds by way of eliminating hazardous radioactive material. Separation process needs careful disposal of radioactive waste to produce radioactive free RE products. Moreover, the processed minerals usually take the form of a rare earth oxide (REO), which then needs to be converted into a pure metal before it can be used to make anything. Given REE's omnipresence in technology, IREL has proved its ability in rare earth manufacturing sector for a long time and provided a range of products. Abundant raw material in terms of RE is available with quantities with IREL.

In conclusion, rare earth minerals play a critical role in the development of green technologies, and their criticality arises from their scarcity, importance, and geopolitical risks. Mining and production need to be done with expertise to address unwanted disturbance in supply-demand balance due to very low concentration of monazite in the suit of other five minerals. Emerging technologies and disruptive technological innovations through R&D efforts, supplementing the demand and production sides, can enable efficient use of Rare earths material and substantial environmental and security benefits. Moreover, continued research and development of alternative materials and technologies for mid-stream and down-stream segments of RE Oxide produced by IREL can be used to establish for further value addition in the country and fill the gaps in transfer of technologies from research to commercial scales. This can help to reduce the reliance on rare earth minerals and ensure the sustainability of green technologies for our Country.
