An Engineering Perspective on Rare Earth Elements

A Literary Investigation of Materials Transforming Consumer Technology & the Energy Industry

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Abstract

From an engineering perspective, Rare Earth elements have the potential to transform technology in previously unprecedented ways. Their magnetic, luminescent, and electromechanical capabilities are allowing electronic devices to become more compact, reduce emissions, operate more efficiently, and cost less to produce and purchase. Such developments are proving beneficial to the economies of many developed nations because of their use in popular everyday consumer technologies as well as industries such as healthcare and education.

Along with this positive impact comes a political overlay that threatens the longevity of Rare Earth use. Presently, Rare Earths are expensive and dangerous to extract. This is largely due to the fact that they are not found together in large concentrations, so it is only economically feasible to extract them with another material, such as coal. The process of extraction is also hazardous and cumbersome; separating Rare Earths from other materials involves processes with high levels of emissions that may be dangerous to human beings if overexposure occurs. On the other hand, nations with more flexible safety and health regulations are investing in the development of Rare Earths and setting themselves apart as production leaders. Nations with more stringent health and safety regulations are becoming dependent on these nations to provide the Rare Earths for their applications. As a result, leaders in engineering industry can only benefit from Rare Earths if they develop systems that use Rare Earths more effectively than other materials commercially available and develop a reliable business relationship with a Rare Earth supplier. This condition is not likely to be encountered frequently in today's intricate social webs and economic systems.

The possibility of extracting Rare Earths through more efficient, safer processes is becoming recognized as a relevant topic of research. Additionally, investigation into alternatives to Rare Earths in some of the more common applications may allow for safer and less politically charged production methods for many 21st century advancements.

Through literary investigation, this research project seeks to highlight the main characteristics that makes Rare Earths desirable from an engineering perspective, proposed alternatives to Rare Earths based on engineering demands, and the direction of the Rare Earth industry as a result.

Which Elements are Rare Earths?

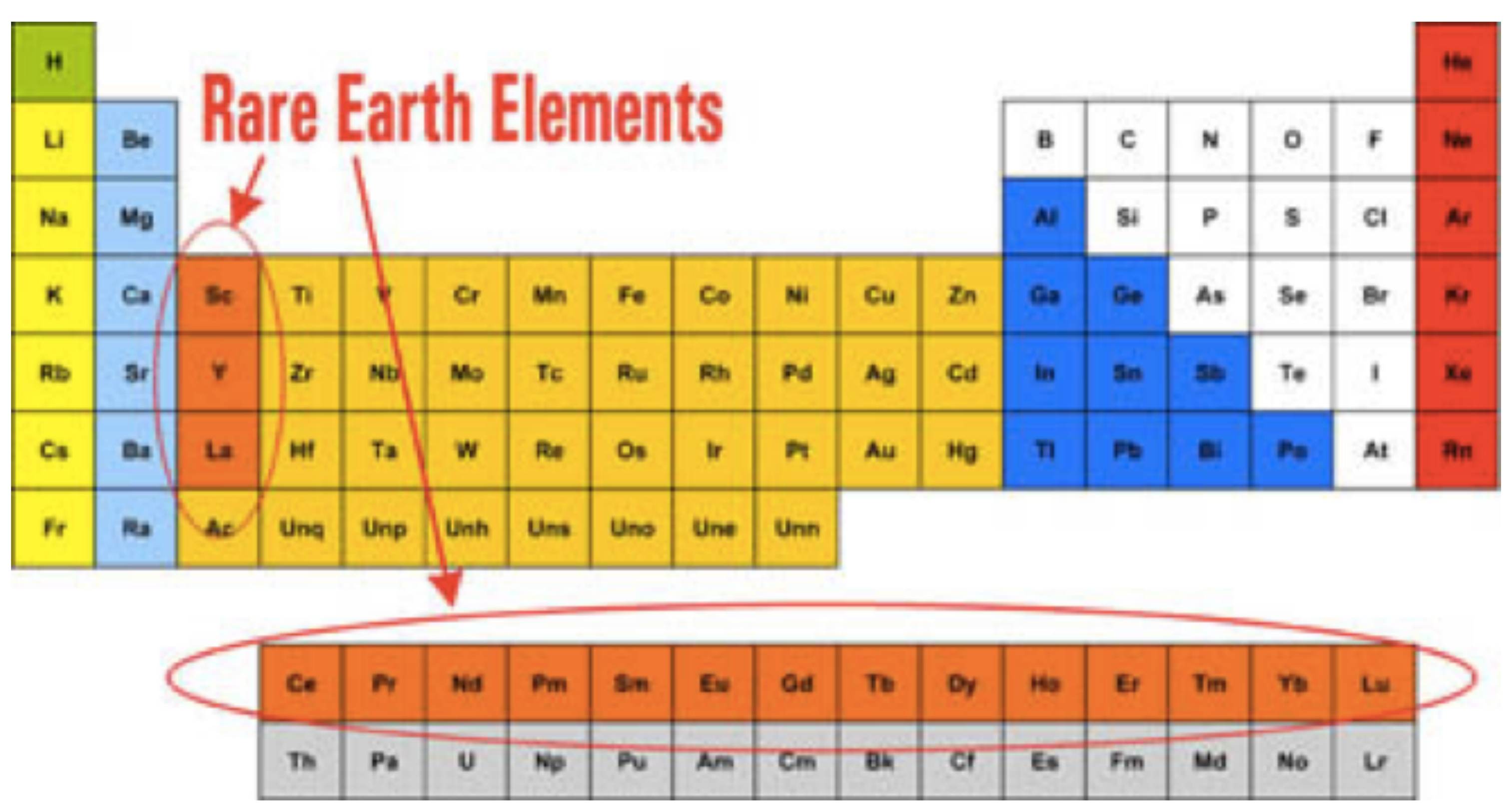


Image 1: Rare Earth Elements in the Periodic Table; Some Rare Earths are Transition Metals and some are part of the Lanthinide Series

How are Rare Earths used?

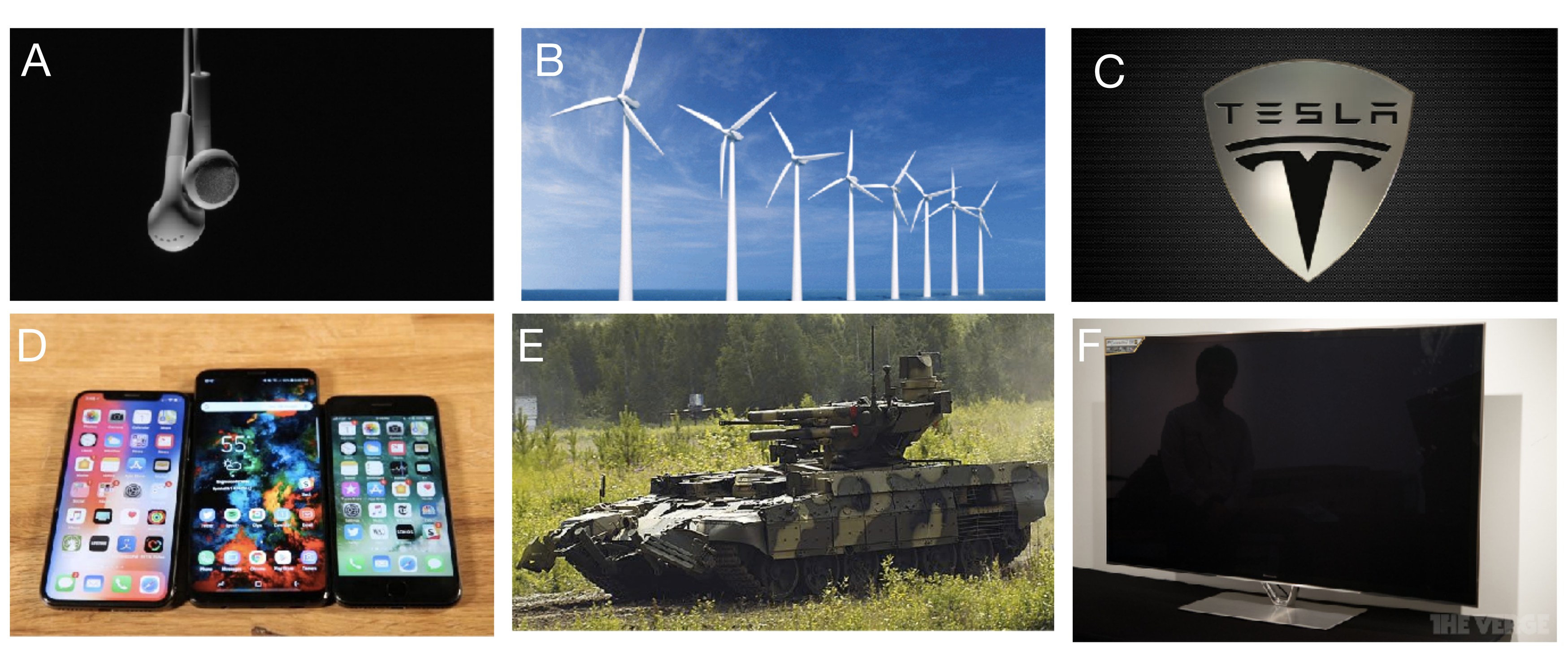


Image 2: Rare Earth elements are used in various technological applications including (A) headphones (B) Wind Turbines (C) Electric/ Hybrid Vehicles (D) Smart Phones (E) Military Munitions, Weapons, & Equipment (F) Plasma Television Sets

References: (Image 1) https://www.powertransmission.com/newsletter/0212/rare.htm; (Image 2A) http://www.pbs.org/wgbh/nova/next/physics/rare-earth-elements-in-cell-phones/; (Image 2B) http://www.machinedesign.com/mechanical-drives/fixing-wind-turbine-gearbox-problems; (Image 2C) https://www.cgtrader.com/3d-models/vehicle/part/tesla-logo-2; (Image 2D) https://www.cnbc.com/2018/03/03/what-to-look-for-when-youre-buying-a-new-smartphone.html; (image E) http://survincity.com/2012/05/tech-uralvagonzavod-for-the-army-of-the-last/; (Image 2F) https://www.theverge.com/2013/4/10/4210556/panasonic-ceases-plasma-panel-development-will-continue-to-make-tvs; (Image 4) http://www.ressourcenfieber.eu/publications/reports/Rare%20earths%20study_Oeko-Institut_Jan%202011.pdf ; (Image 5) https://geology.com/articles/rare-earth-elements/;

What is the future of Rare Earth use?

Many engineers support the efforts that make Rare Earths readily available in order to stay competitive in today's market. Rare Earths have also been a part of research and development regarding devices that will improve the safety and security of populations. For example, engineers are experimenting with the magnetic capabilities of Neodymium, a Rare Earth, to lift furniture and valuables off of the ground during earthquakes to minimize harm or damage to both humans and property. Once irregular seismic activity is recognized in immediate area(s), the magnetic polarity of magnets is adjusted so that similar poles reject each other with enough strength to force objects off the ground. This technology alone could make a life changing impact in locations such as operating rooms.

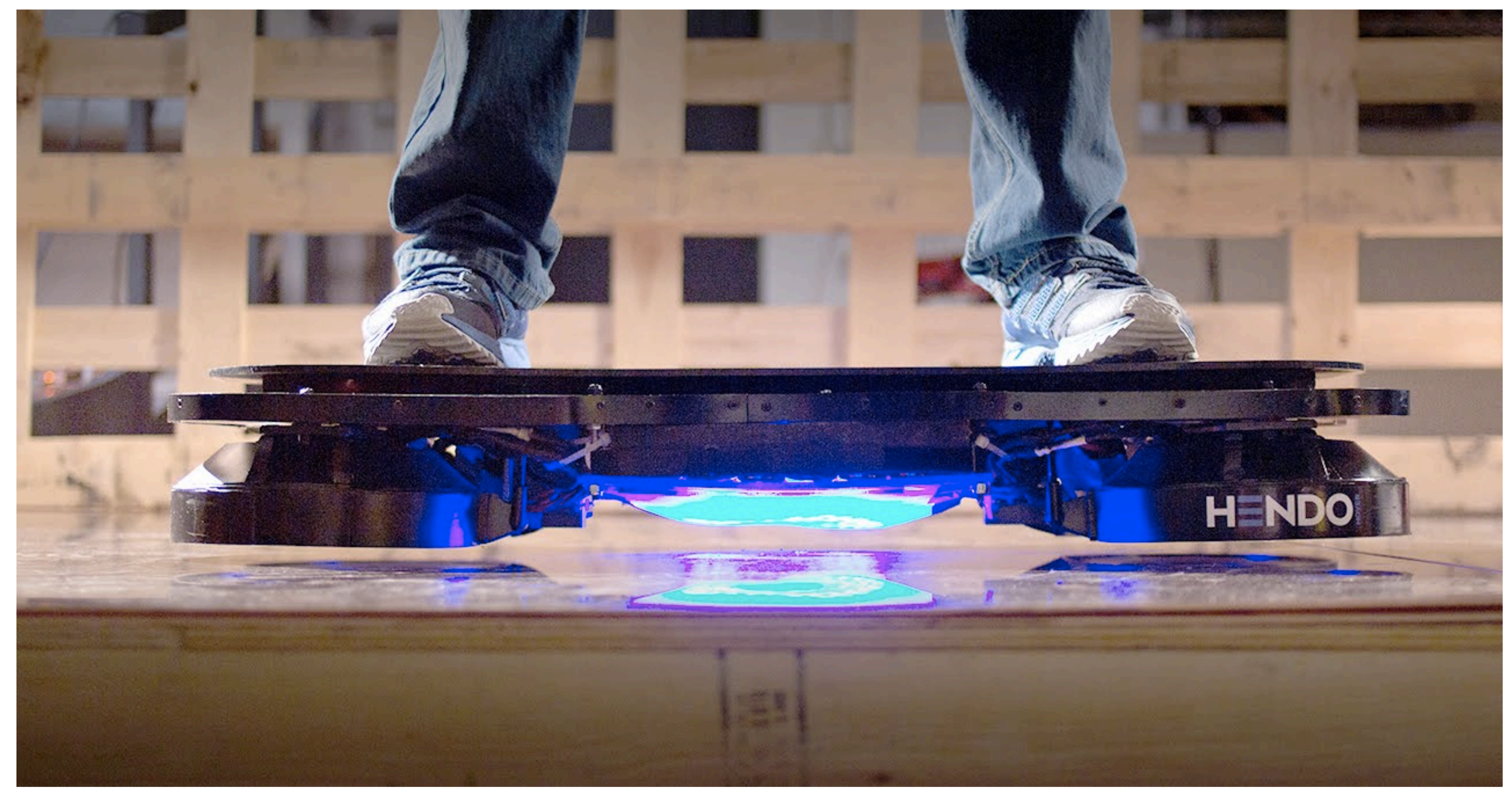


Image 3: Rare Earths can be used to enhanced consumer products or to use hover technology similar to above to lift operating tables in case of seismic activity

Can Rare Earths be Recycled?

Presently, international infrastructure does not support the recycling or frequent reuse of Rare Earth elements from discarded products. Since Rare Earths pile up in landfills before they can even begin to decay, new thought has been put into the development of recycling initiatives for commonly discarded Rare Earth Elements. These new systems will likely need development assistance from civil engineers, structural engineers, mechanical engineers, chemical engineers, etc. to reach optimal operation. This recycling process will need to be effective while also blending into 21st Century societal norms. Additionally, it is known that Rare Earths are a nonrenewable resource, but the Earth's limited supply of Rare Earths remains quantitatively unknown. This idea further justifies recycling.

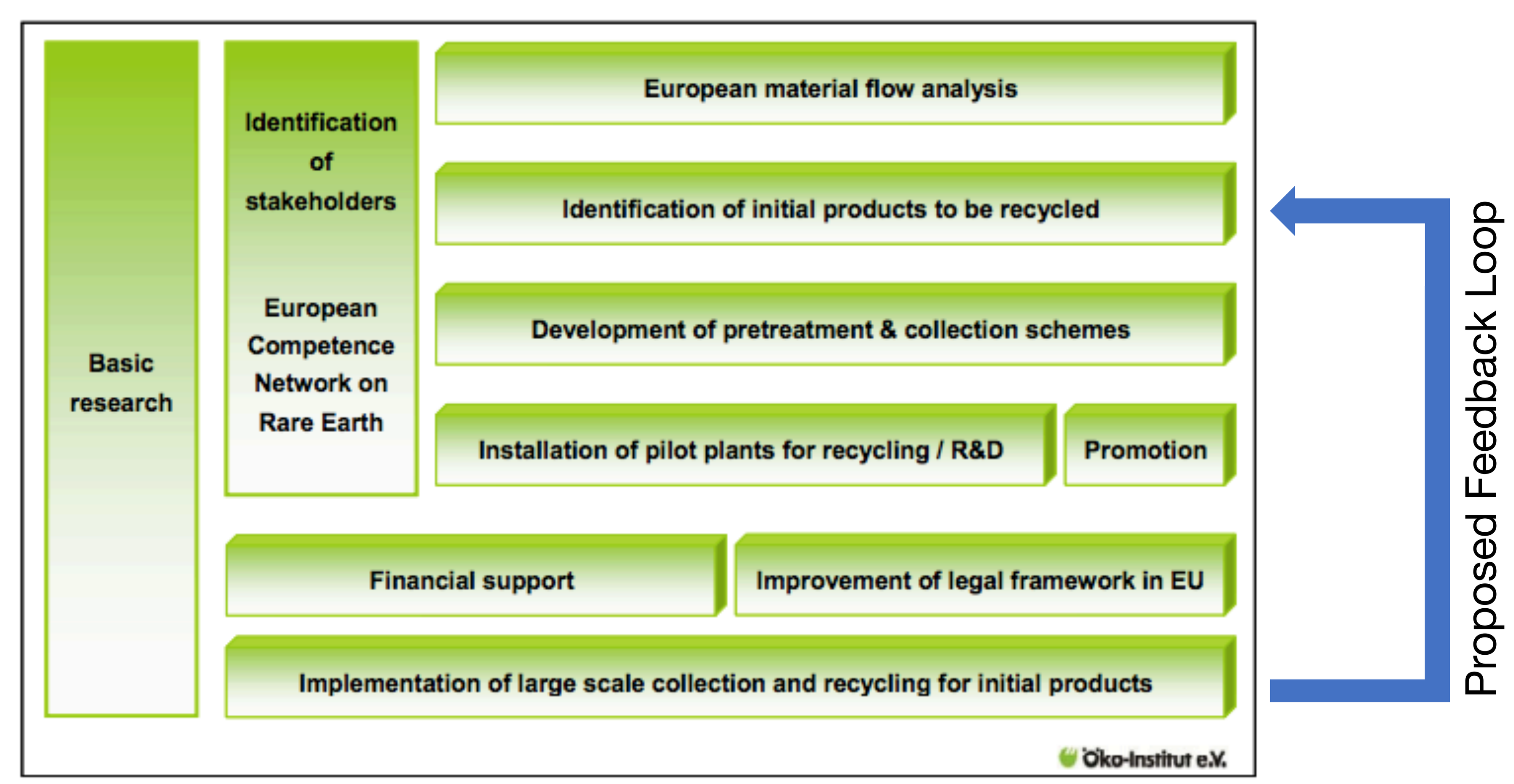
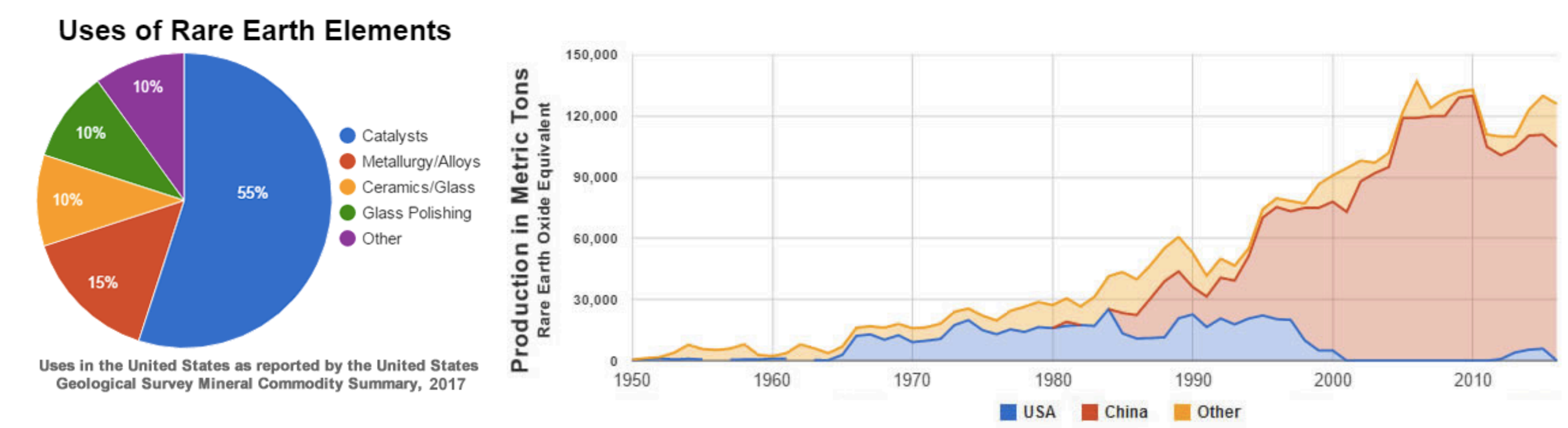


Image 4: A European Proposal for Rare Earth Element Recycling Infrastructure Development; A Proposed Feedback Loop is Recommended for Rapid, Cyclical Improvement of the System

How is Rare Earth Use Quantified?



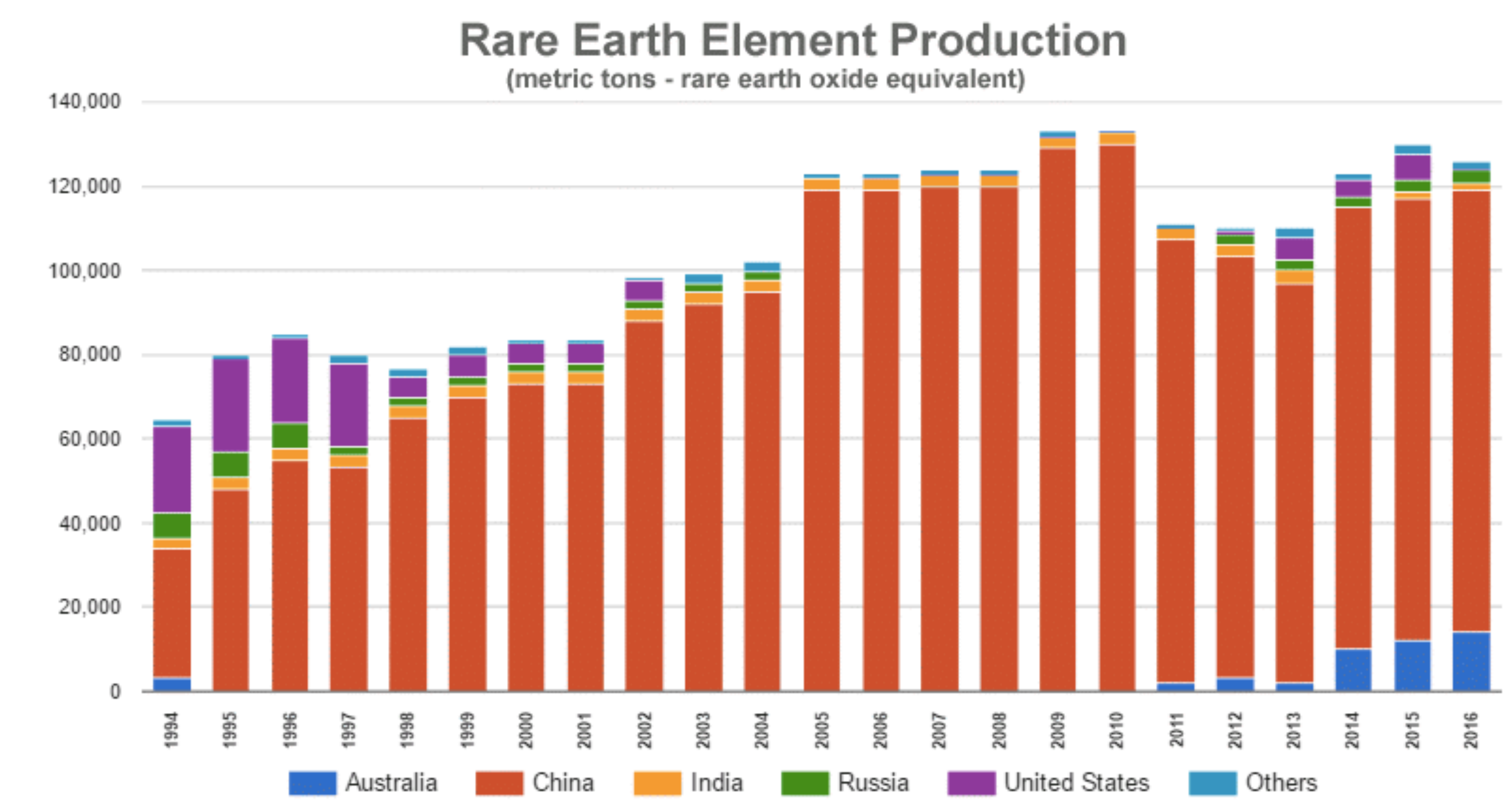


Image 5: Graphical, Quantitative Representations of Rare Earth Development in Recent Years

Conclusions

In conclusion, Rare Earth elements have extreme pros and extreme cons when analyzed from an engineering perspective.

On a positive note, these elements are used to optimize highly technical equipment that transform industries for the better, which is ideal for engineers. Some devices are less hazardous to consumers than their non-Rare-Earth predecessors. Others are lighter in weight, more compact, and more energy efficient as a result of Rare Earths. From an engineering perspective, the development of new technologies to improve standards of living and propose solutions to energy sustainability questions makes Rare Earths not only desirable but key to 21st Century advancement.

Rare Earth elements are also very dangerous and tainted with undesirable political implications. Although many mining locations for Rare Earths have been documented, relatively few have been developed and are successfully producing Rare Earths for use. China presently holds a monopoly on the industry, which is not ideal to some nations who rely on Rare Earths to power their military devices. What happens if those nations find political conflict with China? As an engineer, Rare Earths bring up many safety and health concerns as well as logistical problems. Infrastructure for recycling and powering many electronic devices will need further support, and responsibility for finding resolutions to such issues will likely fall on the engineers.

Pros	Cons
Revolutionary Healthcare Technology	One Nation (China) has a monopoly
Strengthen the Military	Difficult to Mine
Cleaner Energy Harvesting	Dangerous to Mine
Unparalleled Material Properties	Lacking Recycling Infrastructure
Opportunity for Further R&D	Limited Supply

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