

The Chemistry of Reality and the Rise of Rare Earth Wish Factories

written by Jack Lifton | May 25, 2026

“The chemistry and metallurgy dictate the flowsheet – not investor enthusiasm.” – Jack Lifton, Co-Founder & Co-Chair, [Critical Minerals Institute](#) (CMI)

A recurring theme in the reporting of the formation of new ventures for the production of end-user ready forms of those metal elements that are less common in nature, and which are therefore produced, if at all, in much smaller quantities than the structural metals, iron, aluminum, and copper, is that there has been discovered an innovative or disruptive method in the processes used to extract or selectively separate or purify these elements. The claimed innovations in legacy processing, or the disruption and change of the current process, are very often used to justify the creation of a new commercial venture.

However, only a very few individuals in our society are trained in and experienced in chemical engineering and mineral economics, so that it is really not possible for most investors, professional or amateur, to judge the economic value of these new or newly applied procedures to see if the risk of change is greater than the reward for doing so.

[InvestorNews](#) is not an online university attempting to teach chemistry, chemical engineering, or mineral economics.

We can, however, outline for you some common-sense metrics by which you can estimate the probability that an innovative or disruptive technology will be economically valuable, and, if so,

whether an investment in a venture based on such technology is for you a reasonable risk.

I am going to use processes in the contemporary supply chain for rare earth enabled products as an example to assess reports on innovative and disruptive processing technology. My personal experience is that rare earth processing has evolved slowly, and the implications of this should guide U.S. industrial strategy.

The Rare Earth Permanent Magnet supply chain is a critical component of defense systems, clean energy production, and advanced consumer product manufacturing. But it is also a supply chain governed in all instances and for all uses by chemistry, chemical engineering, capital availability, and product qualification cycles – not by policy mandates or market enthusiasm.

Understanding these constraints is essential for making investment choices as well as designing effective U.S. policy.

Let me begin with the central point. Rare earth processing **capability**, as well as capacity, matters because it is foundational to national security, energy transition, and technological competitiveness. The United States wants resilient domestic or allied supply chains. But the pace at which we can build them is limited by scientific and industrial realities. Policy succeeds when it aligns with those realities – and fails when it assumes we can bypass them.

There are five structural constraints that make rare earth processing difficult to reshore.

First, **capital intensity**. A full rare earth chain – from mine building, cracking, extraction, selective separation of mixed rare earths, and separation and purification of each of them to metal and customer-specified alloy production – requires more

than a billion dollars in investment.

Second, **chemical complexity**. The lanthanides are notoriously difficult to separate because they behave almost identically in their chemical reactions.

Third, **environmental permitting**. Cracking and solvent extraction generate waste streams that require stringent oversight.

Fourth, **qualification cycles**. Defense and industrial OEMs require multi-year validation of components that will be present in the ultimate product,

And finally, **China's vertical integration**, built over decades, depresses global margins and discourages new entrants.

Historically, rare earth innovation has not been driven by policy. It has been driven by **new applications**. It was the quest for consumer approval of Color television that first created demand for europium and terbium to generate pure deep colors in cathodoluminescent phosphors in the 1960s. Automotive design issues in the late 1970s created the demand, first for samarium-cobalt, and then for NdFeB magnets, which depended on samarium, neodymium, and praseodymium. Finally, in the late 1980s, the need for temperature-cycle-stable magnets created demand for dysprosium.

The pattern is consistent: **Applications drive chemical separation science and metallurgical developments – not the other way around.**

Despite enormous growth in demand, the core rare earth flowsheet has changed very little in more than 60 years. Mining, cracking, solvent extraction, oxide production, metallization, alloying, and component fabrication – the sequence is the same today as it was in the 1960s.

This stability is not due to a lack of imagination. It is due to the chemistry and metallurgy. The chemistry and metallurgy dictate the flowsheet.

What has changed are the margins. We have better process control. We have more efficient solvent extraction circuits. We have improved metallization technologies. And we have alloy designs that reduce heavy rare earth dependence.

These are meaningful improvements – but they are **incremental**, not disruptive. And incremental improvements are exactly what policy should expect.

Rare earth commercialization was shaped by three forces: war, serendipity, and the periodic table. Defense procurement during the 1940s and 1950s created the first stable demand. Serendipitous discoveries – like europium's red phosphor brilliance – created entire industries. And the periodic table itself imposed constraints: the lanthanides are chemically similar but technologically indispensable.

This history matters because it shows that the industry did not grow through centralized planning. It grew through **contingency and application-driven demand**.

Disruption is unlikely for several reasons.

Chemistry limits alternatives. Capital markets reward predictability, not novelty. OEMs require stability in impurity profiles. Environmental compliance adds time and cost. And China's scale reduces global margins, making it difficult for new entrants to compete. For policy, the implication is clear: **Public funding should support incremental improvements, not moonshots.**

Case Study: NdFeB Magnets

NdFeB magnets illustrate the challenge. They are essential for defense systems, electric vehicles, and industrial motors. But they are also extremely sensitive to impurities. Particle size must be tightly controlled. And qualification cycles can take five to seven years. These constraints, and they are financially onerous, as well as chemically and metallurgically, limit the number of suppliers who can enter the market – even if they have the technical capability.

Case Study: Phosphors

Phosphors show a similar pattern. They require extremely high purity – often 99.999 percent. Their performance depends on precise particle morphology. And solvent extraction remains the only scalable separation method. These requirements make phosphors expensive to produce and difficult to qualify. They also explain why only a handful of producers exist globally.

What Progress Means for Policy

For policymakers, progress in rare earth processing does not mean disruption. It means: **Lower cost per kilogram. Higher yield. Reduced environmental footprint. Improved impurity control. A trained workforce. And long-term procurement commitments that reduce investment risk.**

These are the levels that actually work.

Finally, let me return to the central point. Rare earth processing evolves slowly because chemistry, capital, and qualification cycles demand it.

Policy can accelerate progress – but only if it respects these

constraints. Incrementalism is not a weakness. It is the only viable path to building a secure and competitive domestic or allied rare earth supply chain.