Securing Our Competitiveness

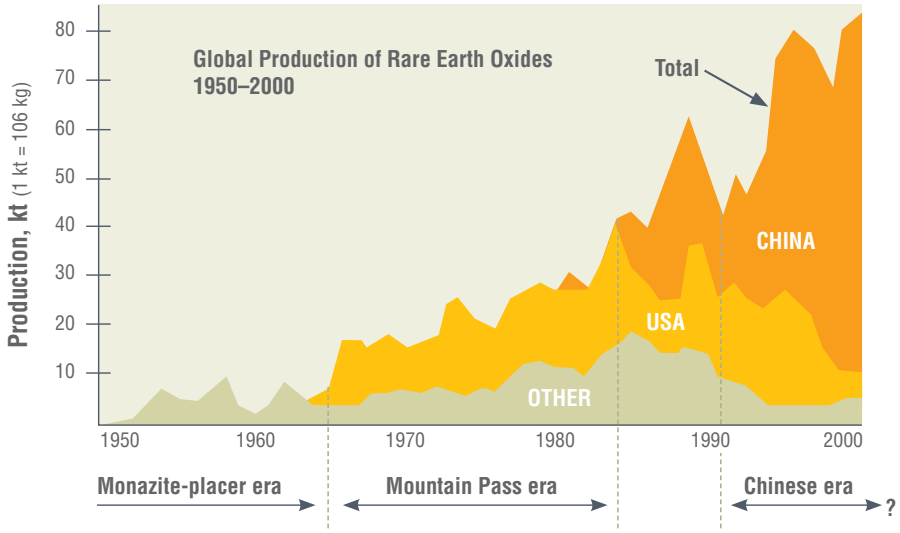
Sustained investment in scientific research and education is critical for energy solutions of the future

Current funding: DoD, DoE, NSF

Rare Earth Elements (REEs) are critical to our energy future

- Thin film semiconductors
- Advanced batteries
- Permanent magnets
- Phosphors

But: Current foreign dominance in REE production can lead to an uncertain future



A sustainable US competitive position requires continued, increased investment in scientific research

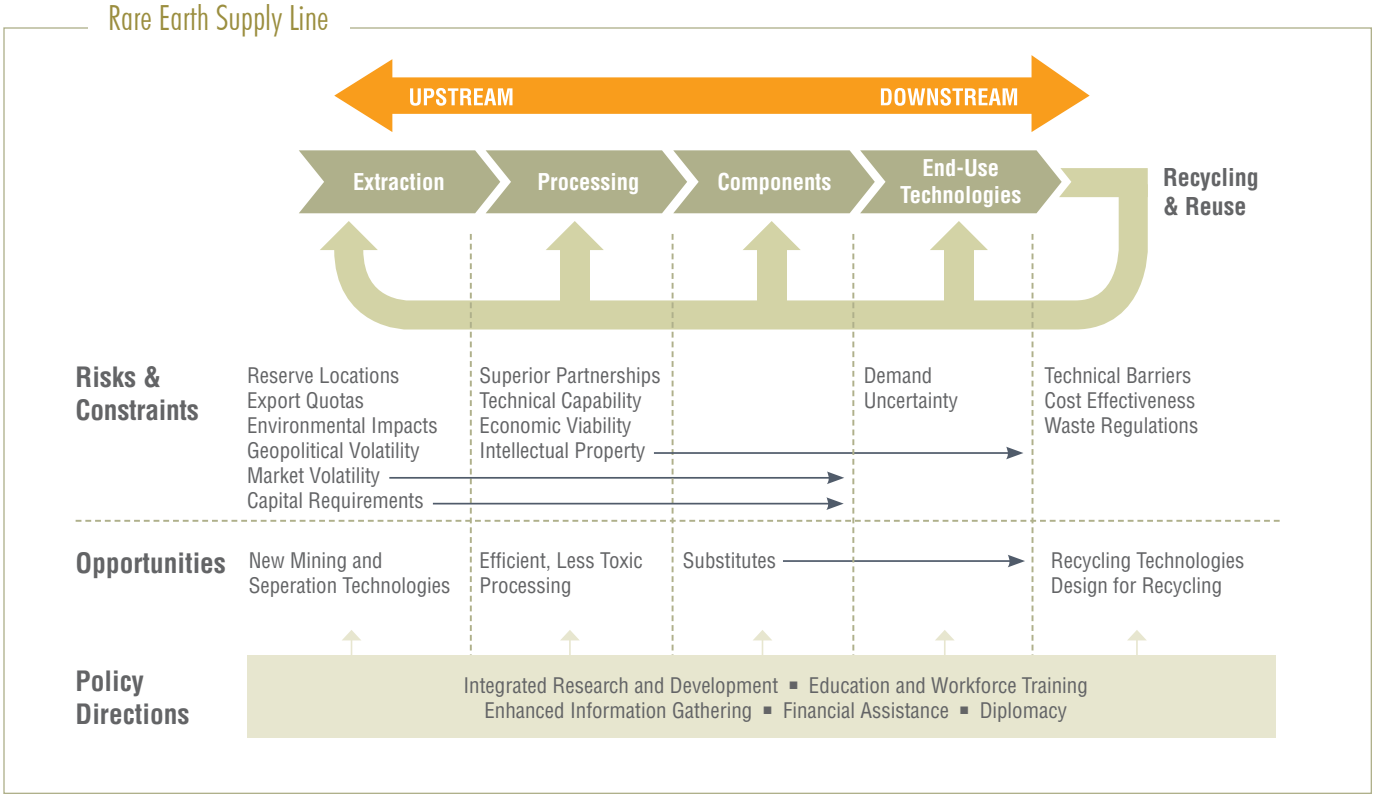
→ **Develop Talent** →

- **Supply Line Enabling** (ex. mining, processing, recycling)
- **Substitution Research**

The federal government has a crucial role in providing scientific research and educational support for programs through the DoD, DoE, NSF, as well as related programs in the national laboratories.

Recent reports released by the **Materials Research Society/American Physical Society** and the **Department of Energy** identify a complex global supply chain for **Energy Critical Elements (ECEs)** that could threaten America's competitiveness in the rapidly-growing technology marketplace. Near term investment in RESEARCH and EDUCATION is crucial to long term sustainability.

Rare Earth Supply Line



ECEs and REEs are Pervasive in the US Economy

There is an increasingly urgent focus on a class of critical/strategic materials being used in consumer, industrial, and defense applications. These "Energy Critical Elements" are often the essential components that make the end-product unique in performance.

Many clean energy technologies—including wind turbines, electric vehicles, photovoltaic solar cells, and fluorescent/LED lighting—now employ materials which are at risk of near term supply disruptions, and in need of alternatives to ensure long term availability.

When widely deployed, these materials and their associated technologies have the capacity to transform the way energy is produced, transmitted, stored and conserved. To meet our energy needs and reduce our dependence on fossil fuels novel energy systems must be scaled from laboratory, to demonstration, to widespread use.

Future investments by the federal government to support basic research in Energy Critical Elements are needed to maintain the projected growth of the ECE domestic markets.

ECE Energy Applications

Lithium (Li) batteries will power hybrid and electric vehicles
Market: currently just under **$1B** (2010); estimated to grow to **$50–100B** by 2015

Neodymium (Nd) permanent magnets drive wind turbine engines
Market: Nd magnets comprise 90% of **$9B** rare earth magnet market—an important piece of the **$45B** global wind turbine market, predicted to be **$60B** domestically by 2015

Tellurium (Te) is a requirement for efficient thin film solar panels
Market: Cadmium Telluride (CdTe) will take a large share of the **$40B** (2010), **$80B** (2015) PV market

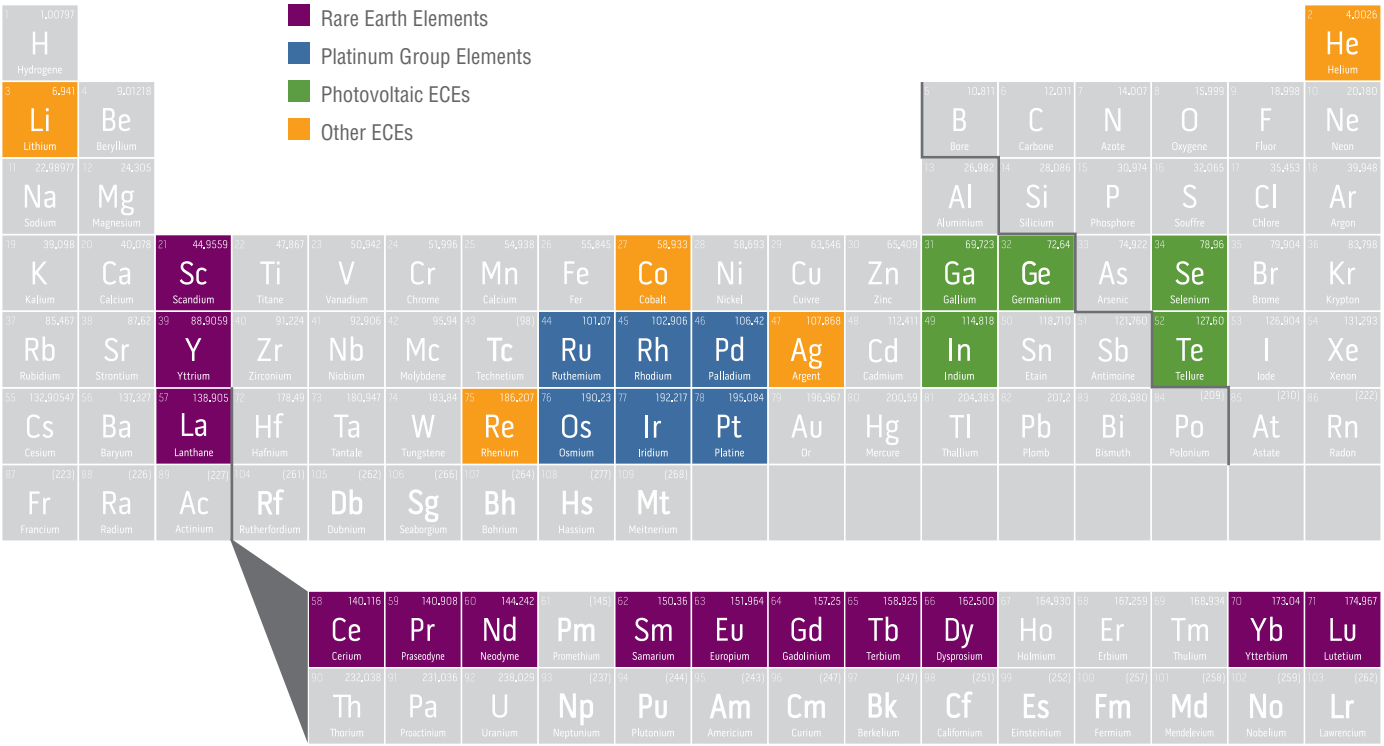
Indium (In) is an important element in light emitting diode (LED) lighting
Market: High Brightness LEDs make up $**5–10B** of **$100B** of the current general illumination market; **$15B** by 2013

Terbium (Tb) is used in new compact fluorescent (CFL) lights replacing incandescent
Market: Majority share of transforming market—at least **$80B** in the near term

Global competitors have shown a willingness to make investments necessary to secure strategic materials and support the valued added processing and creation of new finished products. In the case of REEs, the US previously performed all stages of the rare earth element material supply chain. China is now the predominant source of rare earth ores and processing, generating a potential dominant position with respect to global supply and prices.

Additional competitors will emerge in these dynamic markets in the years to come and a shortage of ECEs could significantly inhibit the adoption of otherwise game-changing energy and defense related products. If this were to happen it could significantly limit the competitiveness of US industries, the domestic scientific enterprise, and eventually diminish the quality of life in the US.

Possible Energy-Critical Elements (ECEs)



Possible Energy-Critical Elements (ECEs) are highlighted on the periodic table. The rare earth elements (REEs) include lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Tb), and lutetium (Lu). The closely related elements scandium (Sc) and yttrium (Y) are often included as well. The REEs are considered as a family, although Pm is unstable, and Ho, Er, and Tm have no energy-critical uses at present and are omitted from our list. Y together with the Tb—Lu form the heavy rare earth elements (HREE), and Sc plus Ce—Gd constitute the light rare earths (LREE). The platinum group elements (PGEs) include ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), and platinum (Pt). Additional ECE candidates include gallium (Ga), germanium (Ge), selenium (Se), indium (In), and tellurium (Te), all semiconductors with applications in photovoltaics. Cobalt (Co), helium (He), lithium (Li), rhenium (Re) and silver (Ag) round out the list.

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