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

Global Production of Rare Earth Oxides 1950–2000

Supply Line Enabling (ex. mining, processing, recycling)

Develop Talent

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.
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) 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 (Yb), 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.