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Nanotechnology's Impact on the Rare Earth Marketplace; The Investment Opportunity

Executive Summary:

- **This report contains an up-to-date overview of rare earth materials and their applications as well as the role of nanotechnology in the rare earth market**. The goal of this report, prepared by Dr. Thomas Kenny, Cedrus Investments' Chief Emerging Technology Advisor, is to provide an entry-level discussion of the 17 rare earth elements, including what they are, their properties and applications coupled with the relationship to technologies emerging in nanotechnology.

- **Applications driving the demand for rare earth elements include portable electronics** (in the form of battery), **transportation** (battery, including lithium-ion, fueling hybrid/electric vehicles and the adoption of high-strength rare earth magnets for high-performance electric motors/generators) **and telecommunications** (optical amplifiers) as well as **clean energy** (wind turbines). Projections of the need for rare earth elements in these applications greatly exceed the current worldwide production of these materials of approximately 150,000 tons a year, with China estimated to account for 95% of the total.

- **There has been intense media interest in the political aspects of rare earth production and the potential impact on many green energy technologies, such as batteries, electric generators and vehicles**. Cedrus encourages investors to monitor this market for opportunities, but at the same time to be careful about over-speculation and hype, leading to over valuations of related stocks. In most cases, Cedrus is excited to report that there are nanotechnology-based alternate solutions to the technical needs in these markets and encourages investors to explore these opportunities for long-term returns.

- **Nanotechnology-enabled alternate solutions can enhance current technology and undercut the dependence on rare earths**.
  - Nanotexturing of electrode materials can improve the current lithium-ion battery technology in terms of efficiency and performance (increasing the energy density and reducing the charging time).
  - By mixing the nanoparticles of a rare earth element with iron nanoparticles, higher-performance magnets can be manufactured at lower cost with less rare earth materials used. There has been academic research on using nanocrystals of ordinary magnetic elements like Iron, Nickel and Cobalt to make rare earth free magnets.
  - Semiconducting quantum dots made by Indium Gallium Arsenide Phosphide (InGaAsP) can replace the rare earth element, Erbium, in manufacturing optical amplifiers for optical telecommunication systems. Moreover, engineers are working to size-select quantum dots of various compound semiconducting materials to enhance the speed, bandwidth and efficiency of optical telecommunications.

- **Through this report, readers will gain a better fundamental understanding of rare earth elements, some appreciation for their impact across many applications, and some insight into emerging opportunities and markets**. This is the second in our series of nanotechnology industry reports, following the publishing of Nanotechnology for Investors 101 on March 28, 2011. Upcoming nanotechnology industry reports include:

  - **Nanotechnology for Alternative Energy**;
  - **Nanotechnology for Water Capture and Treatment**;
  - **NanoMaterials for Energy**;
  - **Atomic Layer Deposition for Manufacturing**