PHYS.ORG

A long-term view of critical materials: from coal to ytterbium

August 29 2012, by Julie Chao

Rare earths and other critical materials are used in numerous clean energy and high-tech products, including wind turbines, hybrid cars, laptops and lasers.

(Phys.org)—When Lawrence Berkeley National Laboratory scientist Frances Houle considers the national alarm that has sounded over the shortage of rare earth materials—critical ingredients in a wide range of clean-energy and medical technologies—she tends not to panic.

"A recent Congressional Research Service report shows that things are evolving fast. The current situation is temporary," she said. "It will sort itself out over time."

That's not to say there isn't a problem. Indeed, more than 90 percent of the world's rare earth elements are now mined in China, and worldwide demand is anticipated to grow from 136,100 metric tons in 2010 to 185,000 metric tons in 2015, according to the June report by the Congressional Research Service. Rare earths are used in numerous high-tech products, from laptops and wind turbines to hybrid cars and a range of defense applications.

However, at Berkeley Lab scientists believe that taking a long-term view is vital for addressing both the current shortage as well as avoiding future shortages of materials that are crucial to U.S. industry. "It's important to remember that a critical material today wasn't a critical material 20 or 30 years ago," said Houle, Director of Strategic Initiatives in the Chemical Sciences Division. "Things that are now 'earth abundant' were in short supply in the 1980s due to problems in Africa. Who knows what the next crisis is going to be in 30 years. To be more resilient to shortages should be the main goal."

Building on its legacy of a team science approach to solving the nation's problems, Berkeley Lab is taking a multidisciplinary approach to the issues. David Shuh, a senior scientist in Berkeley Lab's Chemical Sciences Division, and Houle are the co-lead investigators on a Berkeley Lab project that aims to reduce current shortages and prevent future materials from becoming "critical materials" by taking advantage of advances in nanoscience, chemistry, materials science, computation and theory, physics, genomics and energy analysis techniques—all strengths of Berkeley Lab— and of use of Department of Energy national user facilities located throughout the country to devise innovative short- and long-term solutions to critical materials issues.

Shuh notes that 30 years ago, the United States was fretting over a very different set of critical materials. "Back then it was cobalt, nickel, titanium, which are used to make magnets, alloys and materials for high-performance applications such as in aerospace," he said.

Over the course of history the world has experienced critical shortages in wood, coal, ammonia for fertilizer and metals such as titanium, cobalt and nickel for jets and jet engines. Technological innovation has generally led the way out of shortages.

A nearly 600-page report issued by the Department of Commerce in 1981 titled "Conservation and Substitution Technology for Critical Materials" also lists chromium, columbium (now known as niobium) and tantalum as strategic materials with limited availability, prized for their strength, surface stability and erosion resistance and used in applications such as power plants, jet engines and aircraft. The cobalt supply issue was later resolved by reducing the amount used to make steel as well as finding a substitute material for magnet systems (dysprosium and NdFeB, an alloy with neodymium, two rare earths as it turned out).

Going back even further in history, coal and wood were also once critical materials. Millennia ago, cedar forests in the Middle East were depleted to build palaces and temples and grand kingdoms. More recently, the United States experienced a wood crisis so acute that President Teddy Roosevelt warned of a potential "timber famine," as forests were cleared and wood was devoured to build railroads, rail cars, new homes and more. A famine was averted when railroad technology improved and prices of substitutes, such as concrete and steel, began to fall.

During the Industrial Revolution, England was in control of much of the supply and price of coal. Worried about supplies eventually running out, French scientists began tinkering with solar energy. Auguste Mouchout designed a motor powered by solar energy, impressing Napoleon III enough to receive funding from the monarch and be sent to Algeria to develop a solar-powered steam engine. However, after many years of work, France's relations with England improved and the price of coal dropped; that put an end to financial assistance to Mouchout and he was forced to abandon his project.

Although the development of solar steam power was cut short, technological innovation has generally led the way out of supply shortages, as was the case with ammonia, a key ingredient of gunpowder and fertilizer. After Fritz Haber developed a method in 1909 to fix nitrogen to produce ammonia on an industrial scale, the importance of guano as a fertilizer source quickly diminished. Just a few decades earlier, guano had been in such high demand that laws had been passed and wars fought over control of guano sources.

The problem is compounded now as the Earth's population grows and living standards rise around the world, putting pressure on the supply of natural resources. "These criticality events could become more common if solutions are not developed," Shuh said.

The rare earth metals now in short supply, including dysprosium, neodymium, europium and ytterbium, are used in applications such as magnets, batteries, fuel cells, hybrid engines, lasers and the color for TV and computer screens. Besides rare earths, the clean energy economy is reliant on a number of other elements facing limited and fluctuating supplies, including lithium for batteries, rhenium for metal alloys and several elements used in photovoltaics, such as cadmium, tellurium and gallium.

Indium is another metal that has seen wild fluctuations in price and demand over the last few decades. It is used in LCDs and glass coatings. "Every time they introduce a new technology the price of indium goes nuts," said Houle. "First it went up when laptops were introduced, then it stabilized, and then there was an enormous spike when flat screen TVs were introduced."

Current research is underway to provide alternatives to indium tin oxide (ITO) with other materials systems, namely zinc oxide and graphene.

The long-term view needs to encompass the future as well as the past. Materials need to be considered before a technology is even designed. "A lot of things are going to change over the next 30 years in terms of how we develop new technologies," Houle said. "Before we didn't worry at all about materials availability or environmental consequences. That's what's going to change."

Houle cites the California Gold Rush as an example of doing things without regard to the consequences. "The environmental impacts were quite severe and persist to this day. I point to that as a lesson," she said. "Now we understand that the Earth is finite, and we can't just pick whatever off the shelf and build a technology without understanding the consequences."

Provided by Lawrence Berkeley National Laboratory

Citation: A long-term view of critical materials: from coal to ytterbium (2012, August 29) retrieved 26 April 2024 from https://phys.org/news/2012-08-long-term-view-critical-materials-coal.html