

KENTUCKY PILOT PLANT PRODUCES RARE EARTHS, CONTROVERSY

Extracting rare earth elements from acid waste is proven to be technically feasible in DOE-funded projects, but raises bigger questions as to what the underlying mission is and should be

BY JESSE MORTON, TECHNICAL WRITER

An ancient Chinese proverb reads, the man who says something cannot be done needs to get out of the way of the man doing it.

When it comes to producing rare earth element (REE) concentrates from coal, the proof that it can be done is a mobile pilot plant now processing a quarter-ton per hour of acid-water-waste at a prep plant in western Kentucky.

The pilot plant has been operating since last September. And the leader of the team that researched, designed, trialed, tested and perfected it, Professor Rick Honaker, mining chair, University of Kentucky, said a marketable process for economically extracting REE concentrates from the majority of coal materials found stateside is less than a half-decade away.

“There are some situations where Mother Nature has provided some benefits in doing the expensive part of the process for you that could have economic potential today,” Honaker

said. “We have the circuitry needed using off-the-shelf technology to be able to produce a concentrate that would be commercially salable,” he said. “In terms of producing from the majority of coal materials, we are a little ways out, maybe a couple or three years.”

The story of the pilot plant, and others like it, shows the federal government has an interest in the development of separation technologies and processes capable of extracting REEs. It also shows the tensions between some of the players staking out roles in the growing movement to put the United States back in control of the supply chain of technologies crucial to the nation’s economy and military.

For example, the plant came about rapidly for a solution overseen by an academic institution. It was and is largely bankrolled by the federal government, but as government projects go, it is super cheap. It is a major breakthrough and milestone, and is hailed as such by both the govern-

ment and the universities involved. It is also rightly touted as symbolic of the patriotism of the private companies involved. To critics, though, who also claim patriotic motives, it is seen as a possible money laundering scheme and a means by which the Chinese will further their monopoly over the global REE value chain.

The story starts in 2014, when Honaker first started talking to the federal government about researching the possibility of recovering REEs from coal and coal waste.

In the spring of 2016, Honaker received a grant of roughly \$1 million from the Feasibility of Recovering Rare Earth Elements Program, run by the Department of Energy (DOE) and the National Energy Technology Laboratory, to design and lab-scale test pilot plant technology believed capable of recovering REEs from acid waste.

He led a team that included personnel from Virginia Tech, West Virginia University, Arch Coal, Blackhawk Mining, Bowie Refining, and Eriez Manufacturing and Minerals Refining Co. The prep plants where testing would occur were run by Alliance Coal and Blackhawk Mining. Virginia Tech was to provide the hydrophobic-hydrophilic separation system crucial to the process, which was expected to be patented.

Roughly a year later, Honaker reported the tests revealed the team had produced concentrates containing more than 50% REEs. Later that year, the media would report Honaker said it had produced a 98% pure REE concentrate. The main elements extracted were neodymium, yttrium and scandium.



The pilot plant initially ran for eight hours, and produced 10 grams of concentrate, per day. (Photo: University of Kentucky [UK])

In summer 2017, the team was selected for the next phase and was allotted \$6 million by the DOE program. The companies involved planned to contribute an additional \$1.5 million. The goal was to open a mobile pilot-scale plant at a site in Webster County, Kentucky. Construction began the following spring.

In late 2018, the team reported the plant was operational. Initially, it ran eight hours, and produced about 10 grams of concentrate per day. The team reported it intended to build a full-size processing plant in Hazard, Kentucky, with a deadline of sometime in 2020.

Honaker said the pilot plant proves that the process is technically feasible. “We can produce high-grade rare earth mixes here and we are also working at producing a high-grade scandium product,” he said. “Scandium naturally comes out as a separate concentrate, so it is very easy to produce an upward of about a 60% grade scandium product. We are very confident we can take that up to the 99% requirement.”

That confidence and success is echoed at a project co-run by Texas Mineral Resources (TMR), a project that is part of the same DOE program. TMR reported trials reveal its patented ion exchange process, based on the one used to separate uranium for the Manhattan project, has proven successful at extracting REEs from coal overburden.

“We have been able to separate a liquid solution into its respective components,” Anthony Marchese, chairman, TMR, said. Details, he said, could not be released until after the company had finalized and submitted a report on the results from lab-scale tests of its continuous ion exchange, continuous ion chromatography-based process to the DOE.

Marchese said he was confident the results bode well for the future of the process as a possible marketable solution for REE concentrate extraction. “The answer is yes,” he said. “These projects that are bankrolled



A University of Kentucky mining engineering student monitors the progress of the cleaner separators at the pilot plant in Webster County, Kentucky. (Photo: UK)

by the federal government will serve to give some confidence to the capital markets that there is hope.”

That statement encapsulates a belief about the true intent of the DOE program. “In my opinion, this is all about the separation technologies,” he said. “It is not about REEs.”

Jim Kennedy, globetrotting consultant, columnist, author of a succinct white paper on the Molycorp Mountain Pass REE mine scandal, and the subject of the heralded book, *Sellout: How Washington Gave Away America's Technological Soul, and One Man's Fight to Bring it Home*, half agreed.

“This is about research dollars,” Kennedy said. “The DOE is a government-sponsored money-laundering service,” he said. “Where are you going to send the concentrates to make an oxide?”

The question is not multiple choice. The answer can only be China, he said. By producing REE concentrates from coal, “the United States becomes a resource supplier to the high-tech economy of China,” Kennedy said. “That is our accomplishment with coal: We became China's bitch, again.”

That is, only if developing a technically marketable solution capable of extracting REEs from coal is really possible, of which Kennedy isn't convinced.

He pointed to two major challenges, actinides and grade, that bode poorly for the future of such possible solutions.

First, REEs typically are bound to actinides, radioactive elements. “In almost every case, all of these resources also have thorium and uranium mixed in, sometimes at higher ratios,” Kennedy said. “What happens is you get a couple grams of REEs and you get a couple of grams of thorium.” Thorium, he said, is regulated as if it were plutonium or uranium. “That makes it unfeasible,” Kennedy said. “You have to store it, and you have all those costs and you have the licensing requirements and compliance issues. There is no way coal miners are going to go for that.”

Stored for a set timeframe, thorium gets recategorized by the government, Kennedy said. “After it sits for a certain amount of time, they'll come to you and say, you know what, that's not nuclear fuel, that's nuclear waste, so manage it as nuclear waste,” he said. Which is why all the mining companies that used to supply REEs as a byproduct ultimately ended up burying the concentrates. “The thorium liability issue associated with it exceeded the value of their core business,” Kennedy said.

The actinides issue surfaced recently in international mining news



Two gas-fired kilns used to process REE concentrates at the Lynas Advanced Materials Plant, which has been intermittently closed as the new Malaysian government urges the company to solve what has been called a “radioactive waste” issue. (Image: Lynas Corp.)

covering Westfarmers’s bid to take over Lynas Corp. to the tune of roughly \$1.1 billion. The latter is embroiled in litigation with the Malaysian government over its Advanced Materials Processing plant in East Malaysia. The facility, which has been closed intermittently as the company and the new government sort out permitting issues, generates “radioactive waste” in the course of processing REEs, according to *Forbes*. “The Lynas business model has been controversial since the company opted to mine REE ore at Mount Weld in Western Australia and ship it to Malaysia for processing, triggering claims that Australia was simply exporting a radioactive waste problem.”

Similarly, coal miners opting to process REEs on site would be volunteering to manage a radioactive waste problem, Kennedy said. “Miners would go bankrupt just managing the thorium liability alone.”

Honaker said the actinides issue was not insubstantial. “Thorium actually gets tied up in a mineral form as it goes through a smelting process,” he said. Uranium gets captured, concentrated and treated as a fine waste material.

Fine is the keyword, he said. “It starts out at the parts per million (ppm) level and ends at the ppm level.”

Marchese disagreed with the assessment that the actinide problem nixed the potential economic viability of solutions currently being researched and developed. “No. 1, not all deposits have uranium and thorium,” he said. “No. 2, from our research, uranium is not going to be an issue, it is thorium.”

It is “perfectly legal” to store thorium, he said. “You are not going to get so much thorium out of this that you can’t store it,” Marchese said. “And there are processes where you can actually destroy the thorium.”

One possible solution may be selling thorium to overseas markets, such as India and China, he said.

Next, REEs are typically found in minuscule amounts in many types of ore and mining waste, but especially in coal and coal waste. “You are essentially going to mine a tailings basin that has regulatory and environmental issues with it for these very small amounts of REEs,” Kennedy said.

Honaker mostly agreed. “At a typical rare earth deposit, you would express the REEs in it in percentage points, like 1% to 15%,” he said. “However, we’re dealing with .03%.” That translates to 300 to 1,000 ppm.

One solution would be to extract other marketable materials as well,

Marchese said. “One of the beauties of what we are doing is in addition to pulling out REEs, there are other byproducts. Let’s call them industrial minerals for lack of a better term, that we are also able to separate and sell,” he said. “If you were relying purely on the REEs, given REE pricing today, I don’t think it would be economical.”

Today’s prices will be low compared to those of the future when global demand for smart cars, robotics, advanced computers and weapons, and transhumanist technologies translates into rocketing demand for REE oxides, Honaker said. “What I’ve seen in terms of projections by the major car manufacturers, somewhere around 35% of the total car production in the world by the year 2030 will be electric vehicles,” he said. “Each electric vehicle has anywhere from 1 kilogram (kg) to 5 kg of REEs and when you take a look at the number of cars they are expecting, that will far exceed our current annual supply of rare earths in the world.”

Therefore, “even though you may find certain coal-based REEs not to be economically extractable at this time, it is just like any market-based natural resources industry,” Honaker said. “When the market prices reach a certain critical number, all of a sudden it is very attractive.”

Kennedy said free market economic theory doesn’t belong in the conversation. “Anybody who is not dealing with China, the 90,000-ton dragon in the room, is delusional,” he said. “This is a state-sponsored monopoly that has economic and defense policy goals.”

China, Kennedy said, “runs a state-sanctioned monopoly that has no inherent required minimum costs.”

By monopoly, Kennedy means China has the world’s only value chain capable of turning REE concentrates into oxides at a rate and on a scale large enough to meet global demand. China has 2 million-person cities purpose-built to house that value chain. To get access to the needed REE oxides at the lowest possible cost, tech

companies from around the world move to China, putting their intellectual property at risk. One such company is Apple. The iPhone is “a highly REE-dependent device,” Kennedy wrote in a recent column. With China as the sole source of finished REE materials, the company moved “all of its manufacturing” to China.

This fact likely isn't lost on China. Multiple proverbs from Sun Tzu's *Art of War* reference cutting off the enemies supplies to the extent that they eat their own horses and surrender hope. China is in position to do exactly that, Kennedy said.

“China controls the price of oxides, so they are going to set the price on that,” he said. “China could determine they don't won't U.S. domestic REE producers, and they would simply lower costs below the coal miners' costs.”

Even if China decides it will tolerate a U.S.-based supplier of REE concentrates, the national security implications remain unchanged, he said. That raises questions about the ethics of the DOE program, Kennedy said. “Think about what these guys are doing. They are getting government funding,” he said. “Let's say everything works. They are going to build a system where we can supply China with rare earth oxides and then depend on them for the technology metals. It is crazy.”

It is crazy because those metals are key to all high technology applications, including fighter jets, guided missiles, and semiautomated tanks. The national security implications, Kennedy said, are staggering. “All rare earth metals, alloys, and magnets used by U.S. defense contractors and technology firms can be traced back to China,” he wrote in a recent column. “According to the Pentagon's own Inspector General Report, the Pentagon is incapable of properly monitoring rare earth inputs at the component and sub-contractor level.”

Honaker said the concern was legit, but was a political issue. “Here is a perfect example where are you going

to depend on China and Japan and Russia. Do you want to continue to rely on that structure?” he asked.

Recently, the Department of Defense has been weighing in on the conversation “because a lot of their technologies utilize rare earth materials and those rare earth materials are coming from China,” he said.

And rightly so, Marchese said. “The DoD should be interested in developing this industry to create self-sufficiency in an area that is now controlled by, for lack of a better term, an adversary,” he said.

The solution is twofold, Kennedy said.

First, the federal government must revise decades-old regulations on actinides that ended heavy rare earth production in the U.S., specifically the sections of the United States Nuclear Regulatory Commission's 10 CFR 40 Part 75 that dealt with the mining, plant processing, and storage of uranium and thorium. The regulation was conceived by the International Atomic Energy Agency, and it “applied source material,” meaning nuclear fuel, “regulatory thresholds historically applied to the uranium mining industry to all mining activities,” Kennedy wrote in a recent column. Prior to the regulation, America's supply of REEs came from heavy mineral sands, phosphate and iron deposits. “Due to the costs and liabilities associated with source material, these mining companies diverted these rare earth resources into their mine tailings waste.”

Next, he said, the federal government should get behind efforts to launch a cooperative that establishes a REE value chain stateside.

“The cooperative is getting by-product resources from commodity miners in some other business, even coal, if coal can do it, and it will be owned by end users of finished rare earth products, like magnets, metals, alloys, garnets,” Kennedy said. “And those people are committed to pur-

chase the finished product at cost. Suddenly you've got a solution to China's monopoly. This thing is immutable to China's influence.”

Proponents of American mineral resource self-sufficiency have had at least one receptive audience in D.C. for the last couple of years. In December 2017, President Donald Trump fired off the *Presidential Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*. While it didn't mention REEs specifically, it listed some of the challenges facing American miners in general and noted how dependency on foreign supplies was a national security concern. It solicited ideas and plans and concluded by ordering an official report on as much from the secretary of commerce and the secretaries of defense, the interior, agriculture, and energy, and the United States trade representative.

And as the wheels of the bureaucracy turn, players already vested in the cause dig in to vie for a piece of the action.

One such player, the DOE program, continues apace. And the fruits of its labor are slowly gaining interest from coal miners. “One particular company is Alliance Coal,” Honaker said. “Bob Murry's company is another company that has expressed a lot of interest,” he said.

“Kentucky River Properties, for example, is a company that owns a lot of mineral reserves that coal companies lease from,” he added. “We are in talks about developing a significantly larger pilot plant in one of their facilities.”

Marchese said interest is one of the key gains from the DOE program. “I think it is great that the DOE has undertaken this research trying to help the coal industry,” he said, “because, remember, if you are a coal operator, profits from the sale of REEs and other materials may, in fact, prove to be the difference between having a coal mine that is operational versus non-operational.”