March 20, 2018, 7:00 AM CDT

This Father-Daughter Team Says It Has a Cheaper, Safer Way to Bury Nuclear Waste

Startup Deep Isolation wants to use fracking tech to drill horizontal disposal tunnels a mile below the Earth's surface.

By Ashlee Vance

▲ Elizabeth Muller and her father, Richard Muller, at their home in Berkeley, Calif. PHOTOGRAPHER: JACK BOOL FOR BLOOMBERG BUSINESSWEEK

A case study in the annals of political paralysis has been Nevada's Yucca Mountain, a would-be repository for the country's nuclear waste that's never quite come to serve that purpose. The debate over whether to store spent nuclear fuel inside Yucca has entered its fourth decade, and rumblings <https://www.bloomberg.com/news/articles/2018-03-06/congress-poised-to-skip-funding-yucca-nuke-dump-again-this-year> from the White House and Congress suggest lots more ineffectual arguing ahead. That is, unless the Mullers get their way.

Richard <http://physics.berkeley.edu/people/faculty/richard-muller> and Elizabeth Muller <http://berkeleyearth.org/team/elizabeth-muller/> have come up with one of the more unusual father-daughter businesses in recent memory. On March 20 they announced a startup called Deep Isolation that aims to store nuclear

waste much more safely and cheaply than existing methods. The key to the technology, according to the Mullers, is to take advantage of fracking techniques to place nuclear waste in 2-mile-long tunnels, much deeper than they've been before—a mile below the Earth's surface, where they'll be surrounded by shale. "We're using a technique that's been made cheap over the last 20 years," says Richard, a famed physicist and climate change expert. "We could begin putting this waste underground right away."

The Mullers have four generations living in a four-story house with wood-shingle siding located partway up a small hill in Berkeley, Calif. It's the same house where Elizabeth grew up; Richard has been there for 51 years. In a downstairs study filled with books, including many copies of Richard's physics best-sellers, the Mullers lay out their plan for solving one of America's great technological and political riddles with a homespun charm that feels less reassuring than it should. These folks seem to be making plain-spoken sense, but they don't exactly come off as hard-charging industrialists well-equipped to surmount the political roadblocks in their path.

The U.S. has about 80,000 tons of nuclear waste, mostly sitting at about 70 sites, in aboveground water pools. In the late 1980s the government made plans to store waste at Yucca Mountain by burying it in tunnels 1,000 feet deep. Energy companies have contributed some $40 billion to a Yucca development fund, but that money, like the tunnel development, is frozen. Opponents say the site is too close to an earthquake fault, or that long-term water damage could breach the storage containers, or that Nevadans don't want to live next to a giant waste dump. The plans last stalled during the early days of the Obama administration, when the White House nixed a proposal that aimed to complete Yucca for $96 billion, citing concerns about the container tech.

With each passing year, the U.S. produces an additional 2,000 tons of nuclear waste, and the total is already more than Yucca Mountain was meant to hold. While President Trump has sought a modest $120 million to restart the program, Congress has made clear it's not going to broach the subject in an election year. "It's quite a serious problem," says Rodney Ewing, a Stanford professor of geological sciences who specializes in nuclear security. "As a country, we seem to not be paying attention to the obvious difficulties we have with the waste."

Nuclear waste experts have contemplated deep-drilling for half a century, mostly by proposing to bore straight down into granite and crystalline rock. But tests of these techniques haven't gotten very far, being blocked, on occasion, by the public. These approaches have been deemed costly and possibly unsafe, because stacking containers on top of one another puts so much weight on the bottom drums. The Mullers say it's much cheaper and safer to drill horizontal tunnels, and to do so in shale. They can fit the typical waste canisters (each 1 foot in diameter and 14 feet long) quickly and safely into shale tunnels, they say, given advances in fracking equipment. "Drilling the holes takes a couple weeks at most," says Elizabeth.

Scott Tinker, the state geologist of Texas, has reviewed Deep Isolation's technology and says the Mullers might be onto something. "Isolation in horizontal wells in shale is feasible," he says, and the technology exists to remove the fuel containers if a problem arises or techniques are developed to make use of or clean the spent fuel. But, he says, it's worth worrying about shifts over time in the shale or of larger geographic faults.

It'd be best to keep the tunnels close to existing nuclear waste sites, the Mullers say. The U.S. is so shale-rich that the waste disposal tunnels could be placed near nuclear production sites, so no hauling of waste would be required. The boreholes would also be much deeper than something like Yucca, vastly reducing the chance of radioactive waste leaking into the water supply. "The goal is to get this stuff out of the biosphere, and the farther down you go, the less things change," Elizabeth says. "The waste will have 1 billion tons of rock on top of it and be in shale that has held methane gas and other volatiles for tens to hundreds of millions of years. Things don't leak out." Also, unlike at Yucca, machines could handle all the tunnel work, says Richard: "We're cheaper because we remove a lot less dirt and don't put people underground."

The elder Muller first made his name dealing with radiation much farther away. As a professor at the University of California at Berkeley and senior scientist at the Lawrence Berkeley National Laboratory, Richard did that pioneering research on dark energy and cosmic radiation, including work on projects that eventually earned Nobel Prizes. After he and Elizabeth co-founded Berkeley Earth <http://berkeleyearth.org/> , a nonprofit that measures global temperature and

climate change, he went from being one of the most prominent global warming doubters to one of the loudest voices confirming that climate change is real <https://www.youtube.com/watch?v=Sme8WQ4Wb5w> and caused by humans.

The idea for Deep Isolation grew out of the climate change work. Richard and Elizabeth are convinced that shifting China from coal to natural gas should be a priority, and when their effort to form a gas fracking venture in that country bogged down, they applied their newfound knowledge of drilling techniques to nuclear energy. The Mullers argue that the world must increase its use of nuclear energy to slow climate change and say solving the waste problem would encourage adoption.

Over the past two years, Deep Isolation has been studying waste disposal, filing patents, and hiring 10 consultants and five staffers, including a couple to deal with the legislative morass in Washington. The company's advisers include Steven Chu, the former U.S. secretary of energy, and Per Peterson, a nuclear engineering professor at Berkeley who's advised the government on waste disposal.

Before the Mullers can drill any holes in shale, they have massive challenges to overcome. Stanford's Ewing says Deep Isolation will likely struggle to persuade dozens of communities to accept having a long-term nuclear waste site nearby and to persuade the government to let commercial companies tackle the problem. The two have drafted federal legislation that could lead to private nuclear waste disposal. "The government might allow this," says Allison Macfarlane, former chair of the U.S. Nuclear Regulatory Commission. "The real question is whether such a small startup company would have the resources to go through the licensing over such a long time period."

The Mullers, who've raised only $600,000 so far to explore their ideas, plan to seek about $10 million from investors. They've patented ideas related to drilling and storage techniques but would eventually need to secure multimillion-dollar licenses from each nuclear site, a timely and costly process. They concede their startup is high-risk by the standards of most venture capitalists. They maintain, however, that many of the billions of dollars set aside to deal with the problem of nuclear waste can be theirs if they provide proof of a viable, safe solution.

"It will take about $50 million of investment to get those first licenses," Elizabeth says. "But then you're looking at being a billion-dollar company very

quickly." Her father, who in his climate-skeptic days was funded by organizations with conservative backers such as the Kochs and the Mercers, has endured attacks from all political sides—a skill that could come in handy as the Mullers head to Washington.
