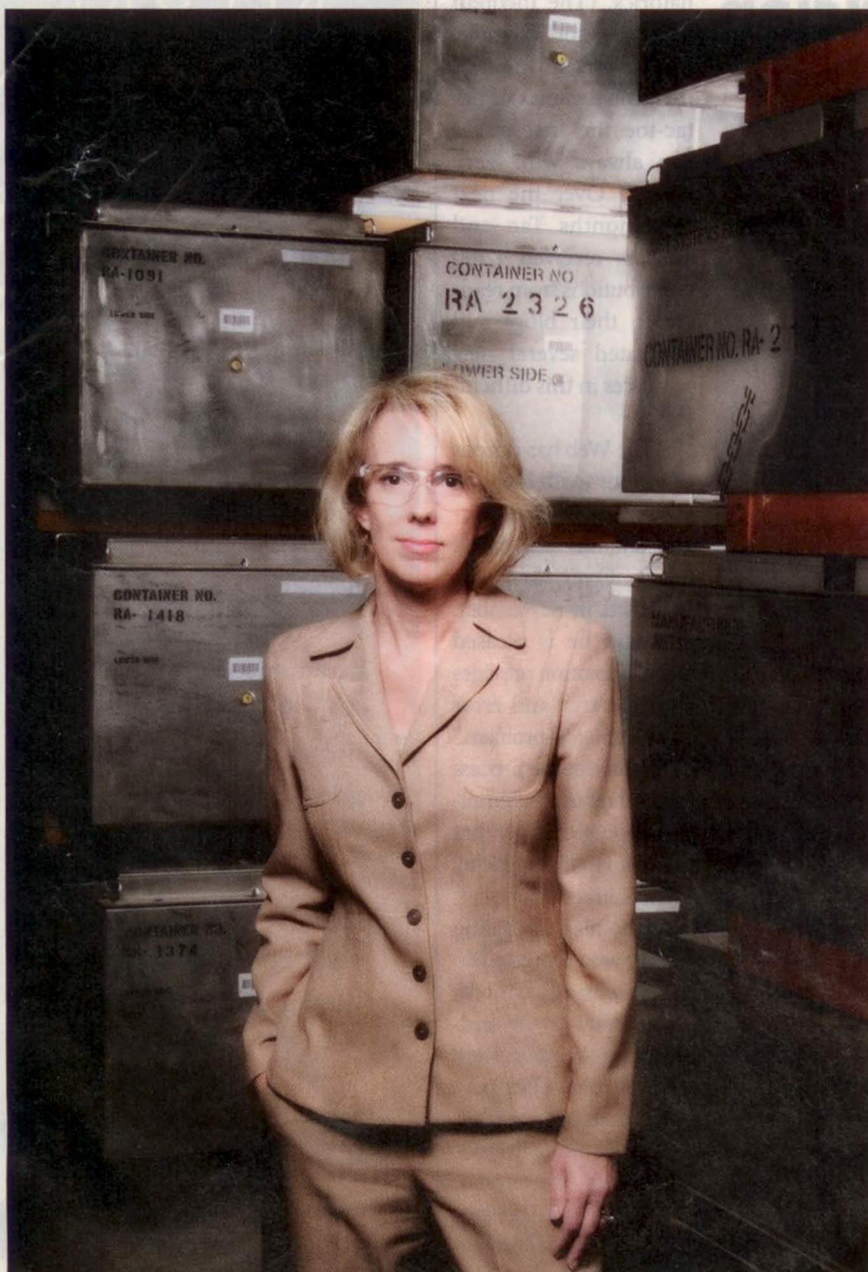
ENERGY&GENIUS

NUCLEAR POWER



Tammy Orr wants to fill those nuclear fuel boxes with GE uranium.

BROWNIE HARRIS FOR FORBES

Riches in Enrichment

GE is trying to blast into the business of making nuclear reactor fuel with lasers. By Jonathan Fahey

GENERAL ELECTRIC BUILDS new nuclear plants, fixes broken ones and makes old ones generate more power. It packages reactor fuel into bundles for nuke operators. There is one lucrative stop on the nuclear fuel train where GE doesn't collect a toll, though: enriching uranium into nuclear fuel.

GE has now decided it wants into the enrichment business and is doing so with an unproved but potentially disruptive technology. It is a highly classified system of using lasers to extract fissile uranium more cheaply and efficiently than methods used today. Uranium is enriched now mostly with arrays of thousands of centrifuges, a mechanical and relatively simple technique even rogue states are able to copy. The laser technology can, if you believe its fans, produce reactor fuel using considerably less factory space and energy than centrifuge enrichment.

Fuel supply may not seem like a big issue with no one building new nuclear plants in the U.S., but a building boom is occurring abroad. There are 53 new plants under construction worldwide, mostly in Asia, according to the International Atomic Energy Agency. The agency predicts the contribution to the world's power from nukes to rise from 370 gigawatts today to 800 by 2030. A large coal or nuclear plant might put out a gigawatt of power and juice a city of 500,000.

Enrichment yields $7 billion a year of revenue, most of it shared among Russia's Techsnabexport, Britain's Urenco, France's

Areva and the U.S. Enrichment Corp., a division of USEC. Despite the sensitivity of shipping enriched fuel around the world, there's a brisk global trade. The U.S. imports 80% of its reactor fuel.

Supply could tighten over the next decade as two large sources of enriched uranium are scheduled to dry up. One is a U.S.-Russia program that dilutes highly enriched uranium taken from weapons down into reactor fuel (which is not explosive); this program is scheduled to end in 2013. It supplies about 10% of the world's power plant uranium, according to the World Nuclear Association. Another 25% of production comes from enrichment factories that use a 64-year-old technology called gaseous diffusion. Most or all of the diffusion plants will be rendered obsolete and shut down by 2017.

USEC operates a big gaseous diffusion plant in Kentucky, but its contract for electricity runs out in 2012, and it is unclear whether it can produce fuel profitably after that. It is planning to build a centrifuge plant to replace it, but the U.S. Department of Energy denied the company's loan guarantee application this summer, and now the future of the plant is in doubt. A Urenco subsidiary has nearly finished a centrifuge plant in New Mexico, and Areva is trying to build one in Idaho.

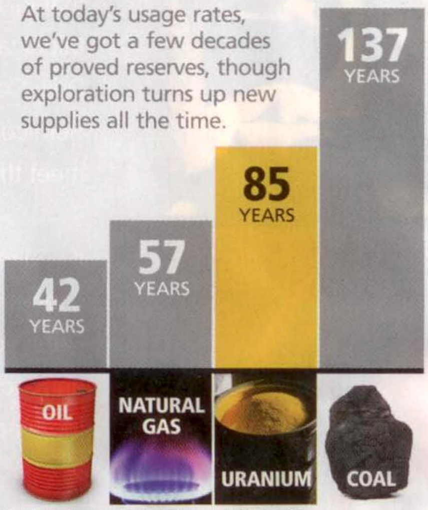
GE believes that enrichment can help it win larger reactor construction deals in developing countries, where governments tend to favor vendors that can do it all. GE acquired rights to its laser-enrichment technology in 2006 from the Australian company that invented it. With Hitachi, its nuclear plant construction partner, and Canadian uranium miner and miller Cameco, GE created a joint venture called Global Laser Enrichment. "This would really close the fuel cycle for us," says Tammy Orr, the chief executive of the joint venture.

When uranium comes out of the ground it is milled into a powder called yellowcake. The uranium in the cake is almost entirely the stable isotope uranium 238. Fission comes from the relatively unstable isotope U-235. Reactors need U-235 in concentrations of 3% to 5%, requiring the enrichment step to make it useful. Once enriched, one pencil-thin, 14-foot rod of uranium has enough energy to provide 56 years of electricity use by a typical American.

All commercial enrichment methods involve first gasifying the uranium with fluorine, creating the gas uranium hexafluoride. The oldest enrichment technology, developed in the U.S. during World War II, diffuses the gas through a membrane. The Russians perfected a far less energy-hogging method that uses centrifuges to spin the uranium hexafluoride at 50,000rpm so that heavier U-238 separates from lighter U-235. Both methods repeat their process hundreds of times, enriching the uranium in tiny increments.

WHAT'S LEFT?

At today's usage rates, we've got a few decades of proved reserves, though exploration turns up new supplies all the time.



Sources: Energy Information Administration; World Nuclear Association.

Kent Williams, a senior researcher at Oak Ridge National Laboratory who has worked on other laser enrichment technologies, says laser concentration can be more efficient simply because it doesn't have to be repeated as often. Still, using lasers to enrich uranium has been tried and abandoned before. The U.S. spent $2 billion on a laser technology called Avlis in the 1980s before giving up. The French tried it, too. In the 1990s USEC worked on the method GE is now perfecting but decided it wouldn't be ready soon enough to replace its gaseous diffusion plant.

The Nuclear Regulatory Commission won't let GE say much about its process, which is called Silex, an acronym for "separation of isotopes by laser excitation." It involves passing uranium hexafluoride gas through a laser beam (GE won't say what color). The wavelength of the laser light can be tuned to interfere only with U-235 and "excite" the molecules, raising their energy level. One possibility, says Oak Ridge's Williams, is that a second laser is then used to blast off one of the fluorine atoms in the molecule. The new molecule, a uranium 235 atom surrounded by just five fluorine atoms, is no longer a gas. It's a solid, and can easily be collected. Williams cautions that the Silex technology could be something entirely different.

GE won't say how much more energy-efficient its method is but says it consumes 75% less floor space. The laser technology is flexible. The price of enough yellowcake to fuel a 1-gig power plant for 12 months has bounced around from $3 million in 2000 to $40 million in 2007 to a recent $14 million (the ultimate fuel cost, including enrichment and other services, is double that). If yellowcake is expensive, GE can fire its lasers more often and grab as much U-235 as possible. Orr compares the process to squeezing oranges. "If you want one glass, you can squeeze two oranges, or you can squeeze just one, and squeeze the [heck] out of it."

GE is operating a test factory in Wilmington, N.C., where it hopes to build a full-scale plant big enough to generate as much as $1 billion in revenue a year. The plant's output by itself would satisfy nearly one-half of current U.S. demand. Orr is not worried about a glut. "The market that we serve is not just a U.S. market, and the global supply and demand curves would say there's plenty of room for this technology," she says. "If the U.S. eventually becomes an exporter, from an energy security perspective, I don't think that's a bad thing." GE's technology wasn't ready in time to meet a 2008 deadline for a federal loan guarantee to help finance the plant, but Orr says GE would apply if more money becomes available.

By early next year GE will have enough data from the test factory to know just how efficient the process can be. Meanwhile, the Nuclear Regulatory Commission is reviewing GE's application to build a plant. A decision is expected in early 2012, and construction would take two years. F

FROM LEFT: OLIVER CLEVE / GETTY IMAGES; STEVE TAYLOR / GETTY IMAGES; TOM TRACY / ALAMY; DON FARRALL / GETTY IMAGES

In the early part of the decade proponents talked breathlessly of a nuclear renaissance in the U.S. Natural gas prices were high, electricity demand was rising, and it seemed that carbon emissions would soon be either taxed or limited. In 2005 Congress passed an energy bill that provided loan guarantees for construction of new nukes on top of tax credits for power produced by the first few new reactors. Utilities fell over themselves planning new nuclear plants—nearly 40 proposals were drawn up.

Four years later the country is where it was a decade ago, at 104 operating nuclear plants (producing 20% of its electric energy). Natural gas prices crashed, making nukes look comparatively more expensive. Carbon remains untaxed and uncapped, and the recession ate into electricity demand, pushing the need for new plants further into the future. Credit markets also dried up, while the pool of government loan guarantees, $18.5 billion, was smaller than the industry hoped for, enough probably for only three plants.

Now, while 17 nuclear projects are still active, only a half-dozen plant proposals are moving at full speed, led by the four projects that are finalists for federal loan guarantees: Southern Co.'s Plant Vogtle project in eastern Georgia; the South Carolina utility Scana's V.C. Summer Nuclear Station project near Jenkinsville, S.C.; Constellation Energy's Calvert Cliffs project in Lusby, Md.; and NRG's South Texas Project. The feds are supposed to announce winners in a few months.

If you really, really want to keep carbon out of the air, it makes sense to build nukes. Solar is still extremely expensive, and wind can get you only so far. It would take a wind farm of 1.2 million acres, bigger than Rhode Island, to produce the electricity that would be put out by the four South Texas Project reactors on its 12,000-acre site.

"We're not going to be able to live without nuclear and coal with carbon capture if you are looking for an economically optimum future," says Revis James, who models future power needs for the Electric Power Research Institute. "We're going to have to build 20 more nuclear units, and we'll need to replace the ones we have. And if carbon capture and storage runs into technical problems, we'll need more."

NUCLEAR OPTIONS

The NRC has received 17 applications for 35 gigawatts' worth of new nuclear plants, equivalent to 35 big coal plants. The finalists for federal loan guarantees:

COMPANY	PROJECT SITE	CAPACITY (GW)	REACTOR
NRG	Bay City, Tex.	2.7	Toshiba ABWR
SOUTHERN CO.	Burke County, Ga.	2.3	Toshiba-Westinghouse AP1000
SCANA	Jenkinsville, S.C.	2.3	Toshiba-Westinghouse AP1000
CONSTELLATION ENERGY	Lusby, Md.	1.6	Areva U.S.-EPR

Sources: Nuclear Regulatory Commission; company Web sites.

Yet, according to James Hempstead, a nuclear analyst at Moody's, every company that is even thinking about building a new nuclear plant faces the possibility of a credit downgrade. That's why Crane's first step was to Washington, D.C. "It's a very short discussion if the federal government doesn't certify the loan guarantee," admits Crane. "We'd stand down within the next few months." The guarantee would cut two to three percentage points off NRG's $3.2 billion portion of the 30-year loan, a savings of $2 billion over the life of the loan.

Crane is hedging his bets still other ways. NRG sells power into unregulated markets, so it doesn't have a pool of captive ratepayers (as Southern and Scana do) who will pay for construction or cost overruns. So rather than build one of the newest nuclear plant designs, NRG chose an older design called the ABWR, which stands for advanced boiling water reactor. The design has been built four times in Japan, all on time and on budget.

Because Toshiba has experience with the reactor, NRG says it will be able to sign a fixed-price contract with Toshiba for construction and also get Toshiba to chip in 5% of the equity. NRG expects to hammer out that fixed price, probably somewhere between $10 billion and $12 billion, by January.

While the ABWR could easily still face regulatory delays and construction problems as it tries to satisfy U.S. standards, it seems to be a safer choice than designs chosen by NRG's competitors in the federal loan guarantee race. Constellation Energy, working through a joint venture with the $90 billion (sales) French utility Electricité de France, plans to build a plant designed by Areva, the French nuclear company. Areva's style of plant is now being built in Finland and facing huge construction delays and cost overruns. Southern and Scana are each building a plant called the AP1000, designed by Toshiba's Westinghouse unit. In October the Nuclear Regulatory Commission announced that parts of the plant would have to be redesigned because of concerns it wouldn't survive a severe shock from outside the plant, like a hurricane.

Crane is taking a safer, though potentially costly, approach to pricing. He wants to sell all the plant's power before he puts a shovel in the ground. He says he has handshake agreements with municipal and cooperative utilities and private companies to do just that. Why would anyone contract for new nuclear power in 2016 when gas prices are low in 2009 and new gas seems to be found every year? Crane says customers in Texas who got burned by volatile natural gas prices over the past ten years are desperate to diversify their power sources. Crane acknowledges his shareholders could be sacrificing upside. If economic activity picks up, natural gas prices are high and carbon carries a price, he would be able to sell his juice for much higher prices than he's negotiating for now.

Of course, NRG still may have a nice cushion, courtesy, again, of the feds. The first 6 gigawatts of new nukes in the U.S. get a bonus: a tax credit of 1.8 cents per kilowatt-hour for the first eight years of production, to a maximum of $125 million a year. Assuming the first of NRG's twin plants (each 1.35 gigawatts) makes the cut, that's $1 billion.

If the market is snubbing nukes, why should taxpayers step in? To proponents like senators John McCain, Lindsay Graham, Lamar Alexander and John Kerry, loan guarantees cost the government nothing if the loans are repaid, and so projects like this one are a cheap way to get carbon-free power.

Guarantees don't cost anything? You might recall that kind of argument back when the federal government was, directly and indirectly, guaranteeing home mortgage debt. **F**