# Spinning a Nuclear Comeback

**A U.S. company is banking on the world's biggest and fastest centrifuges to restore the country's capacity to produce enriched uranium for nuclear power plants at home and abroad**

**PIKETON, OHIO**—It's not easy to get a glimpse of the "American Centrifuge." A visitor must first clear a checkpoint at the edge of the Department of Energy's (DOE's) 1500-hectare Portsmouth reservation in southern Ohio, then pass through several sets of locked and guarded gates. Finally, one reaches the gargantuan, dimly lit centrifuge hall holding the centrifuges themselves—four-story-tall white ghosts, just a few of them so far, looming in the twilight.

Inside each one is a cylinder, called a rotor, that spins faster than the speed of sound. By separating one isotope of uranium from the other, the cylinder slowly increases the concentration of uranium-235. Hooking together thousands of these devices in a cascade yields a fuel rich enough to sustain a nuclear chain reaction.

This technology, a key to acquiring nuclear weapons, is one of the most tightly guarded in the world. In the desert south of Tehran, Iranian engineers are also trying to master the intricacies of the centrifuge. If they succeed, Iran could become one of a handful of nations with a full-scale centrifuge enrichment plant (see map). The United States, currently, is not among that select group. Its membership expired in 1985 when DOE abandoned the centrifuge facility here.

Now the U.S. Enrichment Corporation (USEC), a private company that took over the government's uranium-enrichment operations in 1993, is trying to bring both the building and the technology back to life. The $2.3 billion project would employ thousands of centrifuges and turn the Piketon facility into a source of enriched uranium for nuclear power plants in the United States and around the world. The facility would replace USEC's aging and unprofitable enrichment plant in Paducah, Kentucky, which uses a less efficient technology called gaseous diffusion.

USEC's engineers have retrieved drawings from locked vaults and rediscovered long-forgotten technical skills. "It's like reliving your youth," says Dean Waters, one of the project's leaders. "You almost have to pinch yourself: 'How can I be doing this again?' "

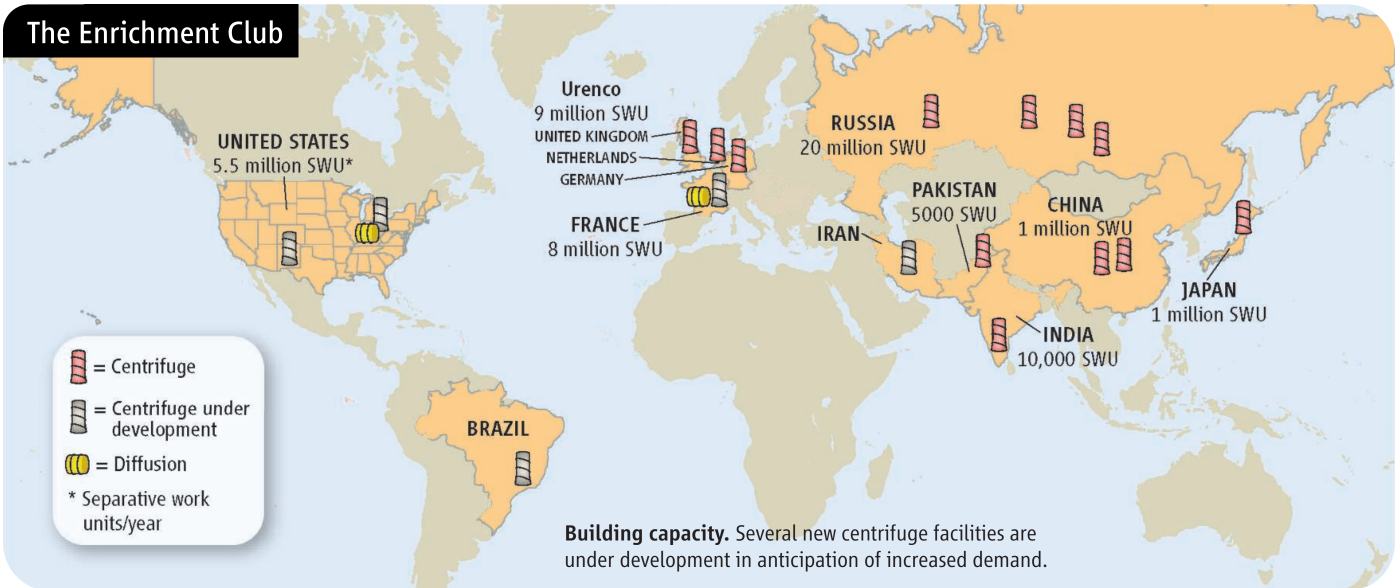
Global demand for enriched uranium is rising, and prices are soaring. Yet the future of the project remains uncertain. A small-scale demonstration of USEC's technology that was due to begin last autumn has fallen nearly a year behind schedule. Even if the technology works, some observers doubt that USEC has the financial muscle to build a full-scale plant. The company also faces increased competition from abroad.

### Born in the USSR

The modern gas centrifuge was born in a Soviet camp for captured German and Austrian scientists after World War II. Ordered by Stalin's government to help build an atomic bomb, they took on the job of acquiring uranium-235, an isotope that comprises less than 1% of natural uranium mined from the earth. Low-enriched uranium, with up to 5% uranium-235, is used in power plants. Nuclear weapons contain highly enriched uranium, in which the concentration of U-235 exceeds 90%.

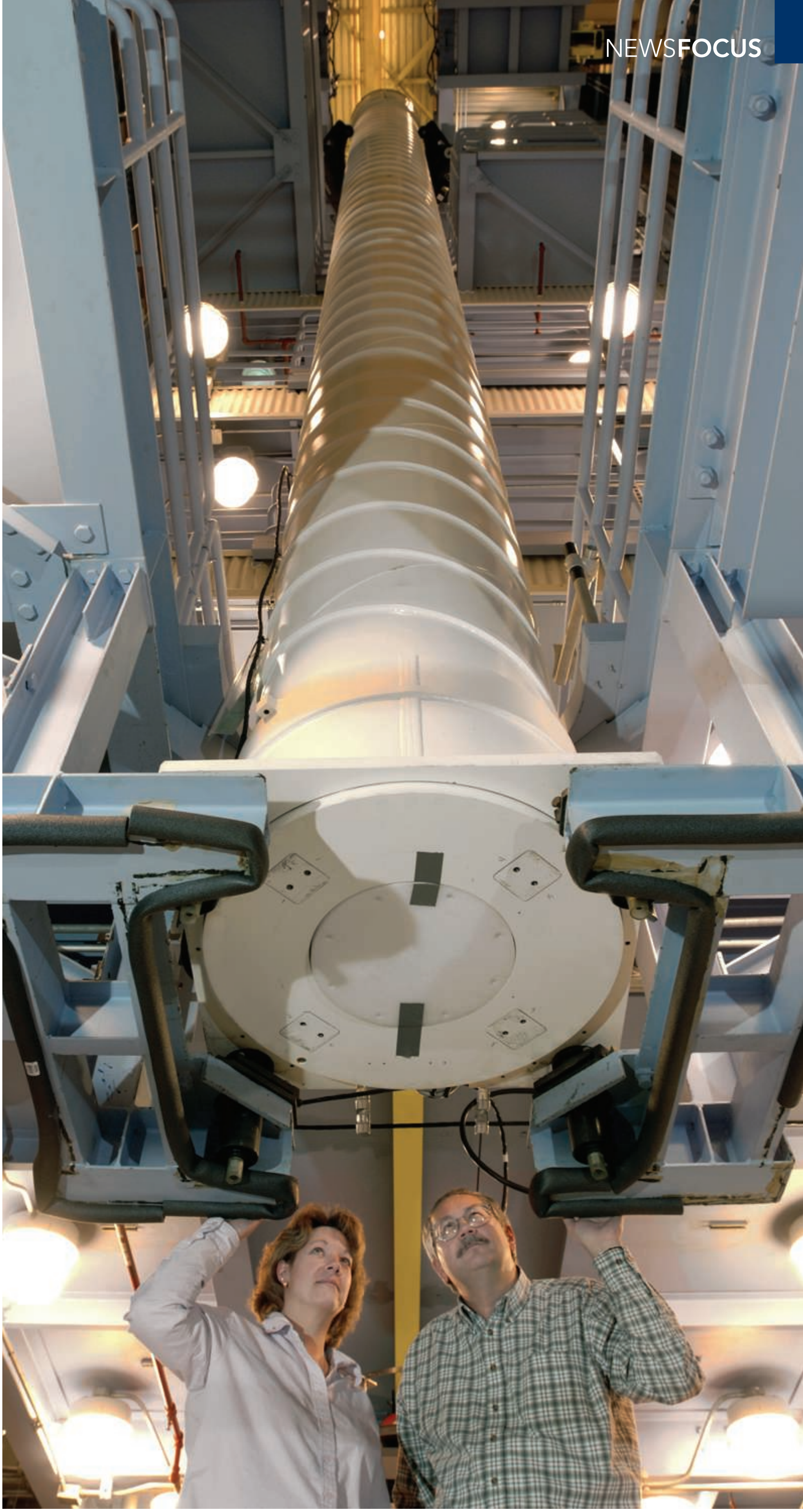
The imprisoned scientists came up with a solution that employs a simple and light tube, balanced on a needle and spinning more than 1000 times each second inside a vacuum chamber. When they fed uranium hexafluoride gas into the cylinder, centrifugal forces pushed the gas outward, against the spinning wall. Atoms of uranium-238, being heavier, concentrated against the wall and also moved toward one end of the rotor. The lighter U-235 moved toward the other end.

The Austrian mechanical engineer Gernot Zippe, one of the leaders of the team, carried this design—in his head, of course—to the West when the Soviets released him in 1956. "At first, I did not want to have anything to do with this highly secret [technology] anymore," said Zippe in a 1992 interview with this reporter. But he soon changed his mind: "I saw that the West was far behind what we did in Russia, and I decided that it would be wrong to leave this to the Russians." Zippe,




**Building capacity.** Several new centrifuge facilities are under development in anticipation of increased demand.

SOURCE: ISIS, NUCLEAR ENERGY DATA (2003) OECD, *WORLD NUCLEAR HANDBOOK* (2003), AND COMPANY STATEMENTS



**Cylinder of secrets.** USEC's Jennifer Slater and Bob Lykowski inspect a centrifuge in Piketon, Ohio. USEC digitally erased some sensitive features from this image.

CREDIT: USEC

who lives near Munich, shared his secrets first with the U.S. government, then with an industrial consortium in Europe called Urenco. The longer a centrifuge's rotor is, and the faster it spins, the more effectively it can separate two isotopes. But this creates huge engineering challenges. Velocities around 600 meters per second, now typical for spinning rotors, test the limits of even the strongest materials. As rotors accelerate, they pass through unstable phases called "critical speeds," where the rotor's shape shifts slightly. The slightest imbalance can cause a rotor to crash catastrophically, and minor stresses will cause bearings to fail.

Each heir to Zippe's invention developed a different version of it. Soviet engineers filled enrichment plants with millions of centrifuges, each one less than 1 meter tall. For many years, they made only small changes to Zippe's original, tried-and-true design. In contrast, Urenco created more powerful machines by increasing both the length and the speed of the rotors. And the U.S. effort, which began in 1960 at Oak Ridge National Laboratory (ORNL) in Tennessee, created the world's largest and most powerful centrifuge. "We started with the original Zippe machine" and improved it, says Waters, who was among the first scientists to work on the centrifuge at ORNL. "Then, within about 6 years, we discovered how to build the kind of machine that we're building today."

That machine, developed during the 1970s and early 1980s, stood about 14 meters tall and could enrich uranium five times faster than any Urenco centrifuge of its time. In the early 1980s, DOE began building a home for it on the Portsmouth reservation, right next to an existing gaseous diffusion enrichment plant. By 1985, more than 1300 machines had been installed in the new facility.

That buildup, however, coincided with the tanking of the U.S. nuclear industry. Faced with plunging estimates of future demand for enriched uranium, DOE officials pulled the plug on the project. For 20 years, the mothballed centrifuges stood idle in silent rows, a mausoleum of secret technology. "We had the feeling that someday those buildings would be like Stonehenge," says Houston Wood III, a centrifuge expert at the University of Virginia in Charlottesville who worked on the project. "People would come and wonder, 'What were they thinking?' "

### Recovered memories

There is, in fact, a Stonehengian quality to the Piketon plant. Its scale is massive—the buildings cover 160,000 square meters—and its peculiar architectural features reflect the unique demands of its very tall and very fragile tenants: doors five stories high, for instance, and concrete floors that float on a vibration-absorbing foundation.

From 1985 until last year, these buildings were used only to store containers of waste from the nearby gaseous diffusion plant. Now they are coming back to life. Over the past 2 years, the centrifuges were dismantled, shipped to a classified landfill at the Nevada Test Site, and buried. The first of a new generation of centrifuges, identical-looking but quite different inside, are now arriving.

The revival began in 1999, when USEC decided to bet its future on centrifuges after the rising cost of electricity made USEC's 50-year-old gaseous diffusion plant ruinously expensive to operate. The company went looking for people who knew something about the technology. "A surprising number were still at Oak Ridge," says Waters, one of many nearing retirement. "Frankly, I don't think we would have resurrected this had that not been the case."

USEC signed up ORNL as a partner. Waters helped retrieve piles of old technical reports, computer programs, and centrifuge-related equipment from a laboratory vault. The know-how stored in human brains was even more valuable. "You can never put precisely into a document everything that you know," says Waters.

The team set about recreating its earlier centrifuge, with one crucial difference. The new machine features a rotor made from woven carbon fiber rather than fiberglass. This stronger rotor can spin faster—how much faster, USEC officials won't say. But it has made the world's most powerful centrifuge even more so.

A centrifuge's ability to enrich uranium is measured in "separative work units" (SWU). According to Daniel Rogers, director of the plant in Piketon, each new centrifuge can perform 350 SWU per year. By contrast, the machines that sat unused in the Piketon plant for 20 years were rated at about 200 SWU per year. Julian Steyn, president of the consulting firm Energy Resources International in Washington, D.C., says the latest Urenco centrifuges, which have carbon-fiber rotors about 6 meters long, can run at 70 to 80 SWU per year.

**Expired.** The 1300 centrifuges at the Piketon facility in 1985 were never used; they are buried in a classified Nevada landfill.

### Is tall and fast a winner?

USEC officials like to compare their machine to a Mercedes. In contrast, says one, Urenco's resembles a Volkswagen. A company slide show states it bluntly: "Taller and Faster is Better."

USEC will need only one-fifth the number of centrifuges as Urenco to produce the same amount of enriched uranium. But USEC's large centrifuges may be more costly to manufacture and to maintain. And reliability is even more important, says Steyn. USEC's centrifuges will have to operate flawlessly for decades to hold their own against Urenco's stable of centrifuges.

Waters believes that his new centrifuge will prove the doubters wrong. In the 1970s and 1980s, he says, "we achieved reliability that was on the same order of magnitude as Urenco's. We have several examples of extremely reliable cascades. The people who did that are working on this program today."

USEC is also facing a financial pinch. In U.S. Securities and Exchange Commission filings last month, USEC estimated that a full-scale centrifuge facility will cost $2.3 billion. The company admitted that it will need "some form of investment or other participation by a third party and/or the U.S. government" to get a new plant running.

Most observers don't think Uncle Sam is likely to help out. Once a tightly held government monopoly, the business of uranium enrichment is now—at least in the United States and Europe—dominated by commercial priorities. Failing companies face bankruptcy rather than a government bailout.

For the first time, USEC also faces possible competition on its own turf. With its eye on the U.S. market, Urenco has acquired preliminary approval for a full-scale centrifuge plant and has broken ground near the town of Eunice, in southeastern New Mexico. Production is scheduled to begin in 2009. Meanwhile, GE Energy is testing another approach to uranium enrichment in Wilmington, Delaware, using lasers that are tuned to excite particular isotopes. GE Energy licensed this technology from an Australian company. "There's not enough enrichment capacity in the West," explains Steyn. Many U.S. power plants currently use fuel that originally came from the Russian stockpile of highly enriched uranium. But the deal that makes this possible will expire in 2013.

Some nuclear proliferation experts worry that the Piketon facility could be a tempting target for nations trying to develop nuclear capabilities. Urenco, the first of the commercial enrichment companies, was the source of centrifuge technology that aided nuclear efforts in Pakistan and other countries. In particular, A. Q. Khan, a Pakistani metallurgist who worked for a Urenco contractor in the Netherlands in the early 1970s, obtained details of centrifuge design before returning to Pakistan, where he led that nation's successful efforts to create a nuclear bomb.

Noting that USEC, like Urenco, plans to rely on contractors to manufacture most of the centrifuge components, Harvard University proliferation researcher Matthew Bunn says that "the more different sets of people have their eyes on parts of the centrifuge, the more chance there is for that technology to leak." Rogers, however, says that USEC has tightened security in recent years to address growing proliferation concerns.

USEC's next step is construction of a small pilot cascade, with up to 240 centrifuges, inside the Piketon plant. The pilot will persuade potential investors that the American Centrifuge is both technically and economically viable, says Rogers. It's running slightly behind schedule: The "lead cascade" was expected to start up last fall, but USEC is now aiming for the end of this summer.

Virginia's Wood hopes that it succeeds, putting the United States back into the big leagues of uranium enrichment. "USEC has a tough road, but I'm pulling for them," he says. "I would hate [for us] to be the only country in the world that doesn't have a centrifuge plant."

**–DAN CHARLES**

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CREDIT: USEC