

Nuclear is here ... and here and here

East Tennessee hosts a nuclear resurgence

By Leo Williams

Oak Ridge National Laboratory

In fall 2020, California-based Kairos Power announced plans to build an advanced nuclear demonstration reactor within the site of the former K-25 uranium enrichment plant in Oak Ridge.

It was a good location for the company. The decommissioned K-25, now named Heritage Center Industrial Park, came with impressive infrastructure, including ample electricity from the Tennessee Valley Authority, abundant water from the nearby Clinch River, and more than 11 miles of rail line connected directly to the Norfolk Southern system. Interstate 40 was less than five miles away.

Perhaps more importantly, the location gave Kairos' scientists and engineers close access to an unmatched pool of nuclear expertise. ORNL, which helped start the nuclear age more than 80 years ago and remains at the forefront of nuclear research, is all of five miles away. The University of Tennessee, Knoxville, which hosts a prestigious nuclear engineering department dating back to 1957, is just 30 miles down the road. And the federally owned TVA, which has operated nuclear power plants since 1974, is developing its own next-generation nuclear reactor about three miles away.

In particular, though, the company wanted to be near a national lab, according to its co-founder Mike Laufer.

"The big decision for us was where we were going to put the Hermes reactor," he said. "For that, we pretty quickly narrowed down that we had a strong preference to be in close proximity to a national laboratory, with capabilities that could augment our own infrastructure."

Hermes will be a 35-megawatt molten salt-cooled reactor that uses a new kind of uranium fuel called TRISO — short for tristructural isotropic particle fuel. The billiard ball-sized TRISO pebbles will consist of uranium, carbon and oxygen particles surrounded by carbon- and ceramic-based materials designed to prevent the release of radioactive fission products. The reactor will not produce electricity; rather, it will demonstrate the company's technology before Kairos moves on to building much larger commercial reactors.

A torrent of new businesses

When Kairos made that announcement in 2020, it was among the first of many new East Tennessee businesses looking to join a resurgent nuclear industry. Other nuclear newcomers include:

- TRISO fuel manufacturer TRISO-X, which announced in April 2022 that it would place a fuel facility in Horizon Center Industrial Park, which is adjacent to Heritage Center.
- Type One Energy Group, which announced in February 2024 that it would build a prototype fusion device called Infinity One at the site of TVA's retired Bull Run Fossil Plant just outside the Oak Ridge city limits in Anderson County.

ORNL played a key role in these three announcements, owing to its role in the development of particle fuels and fusion energy. TRISO-X, for example, developed the prototype for its fuel fabrication facility at ORNL.

Then in September 2024, Orano USA announced Oak Ridge as the site of a new multibillion-dollar uranium enrichment facility, the single largest investment in Tennessee history. Orano's 750,000-square-foot plant will be built on a 920-acre site transferred to the company by DOE. It's expected to create more than 300 jobs.

According to the East Tennessee Economic Council, there are more than 200 nuclear-focused companies doing business in Tennessee at more than 350 locations. More than 150 of those companies are doing business in and around Oak Ridge and Knoxville.

The number is rising steadily, according to the council's president and CEO, Tracy Boatner.

"We get calls regularly," Boatner said. "I know the Chamber, ORNL, TVA and the state Economic Development Department do. Even UCOR said recently that they get calls probably on a weekly basis from companies that are interested in moving here."

The Oak Ridge Chamber manages economic development inquiries for the city of Oak Ridge. Chamber President and CEO Christine Michaels echoed Boatner's experience.

"Last week it was every day," she said earlier this year. "And they were not all the same company. Right now we have probably half a dozen very active prospects and others that are in various stages of exploration for sites."

ORNL catalyzes growth

According to Mickey Wade, ORNL's associate laboratory director for the Fusion and Fission Energy and Science Directorate, the lab is actively involved in promoting the region's nuclear industry and consulting with nuclear businesses that move into the area.

“Getting these companies here has always been a priority of the lab,” he said, “and you can see that with the number of nuclear companies that are in the East Tennessee region.

Wade said both larger and smaller businesses are critical to the success of the region’s nuclear ecosystem. He said Kairos, with its embrace of molten salt technology, and Type One Energy, which is developing advanced fusion technology, are of particular interest to the lab.

“These are examples in fission and fusion that we feel are very important for us to be connected with because they are sea changes about how you do nuclear energy in the future. These are approaches that we feel like the lab is very well suited to be engaged with.”

Wade said that while large facilities are important to the lab, a robust ecosystem of smaller support businesses in the supply chain is also critical.

“Ultimately in an industry, it is about the end product, and the companies that really make it happen are those that are on the leading end of the supply chain.”

Wade said the lab is especially on the lookout for businesses in the supply chain that have the technical and business know-how to succeed.

“Those companies really need the national labs to get them over the hump with regard to their idea,” he said, “and we need them because they’re telling us what’s important, what science and technologies we need to develop to enable the U.S. industry in the future.”

A natural home for nuclear businesses

East Tennessee offers a particularly attractive business environment for a nuclear renaissance. Not only does it already boast a wealth of nuclear expertise, but the K-25 cleanup provided 2,000 acres of industrial property with existing infrastructure, with another 440 acres of developable land available at the recently created Horizon Center.

According to Boatner, the decades-long cleanup at Heritage Center, proximity to ORNL, and TVA’s effort to locate small modular reactors along the Clinch River helped focus attention on the area, as did the state’s creation of a \$50 million Nuclear Fund in 2023 to support the nuclear industry.

“The catalyst for the growth of nuclear here in Oak Ridge has been the interest in TVA and the fact that that UCOR and the Department of Energy Environmental Management program have cleaned up the former K-25 Site,” she said. “Governor Lee’s \$50 million

investment to recruit nuclear companies has also significantly amplified Tennessee's appeal as a prime location."

In addition, she noted, Oak Ridgers are especially welcoming to nuclear businesses. Kairos co-founder Laufer agreed.

"I would say the community in Oak Ridge has been incredibly welcoming," he said. "Our expectations were high, but everything has been met and exceeded in terms of the engagement and not just the acceptance but a lot of the excitement that we have seen from the local community."

Good for the region

That openness will almost certainly boost the regional and state economies, say local officials.

Their assessment is supported by a report released by the Southeast Nuclear Advisory Council and conducted by E4 Carolinas in February 2024. The report looked at the nuclear industry's economic impact in five states: Tennessee, North Carolina, South Carolina, Virginia and Georgia. It concluded that nuclear businesses and their suppliers in Tennessee employ more than 29,000 people who bring in \$2.5 billion in salary. The economic output of these businesses and their employees totals nearly \$8 billion.

Add in the effect of this spending on local economies — the meals, movies, vehicles and so on that these employees spend their money on — and the total comes to more than 40,000 Tennessee employees making \$3.2 billion and generating nearly \$10 billion in economic output. Tax revenue from all this spending comes to \$1 billion.

The report also notes that jobs created by the nuclear industry pay substantially more than most other jobs. Average pay across the region for nuclear workers averaged nearly \$90,000, which is nearly two-thirds more than the average job.

First there was TVA

Boatner said community efforts to promote the industry grew naturally out of TVA's interest in building two or more small modular reactors at the Clinch River location.

Small modular reactors are a relatively new idea in the nuclear world. Besides their size — the reactors under consideration are designed to produce about 300 megawatts of electricity, less than a third that of TVA's other reactors — what distinguishes them is their standardized designs.

In the past, nuclear power plants varied substantially in design, making each unique and making it difficult to achieve the cost benefits that come with standardization.

"If you go back to the current commercial nuclear industry, virtually every plant is different," said TVA's Greg Boerschig, vice president of the Clinch River Project. "The equipment is different, much of the engineering is different, and that adds a lot of expense."

"The more of the plant that you can maintain standard — parts, engineering, structures — that brings the cost down."

While the concept of these small reactors is relatively new, one technology being considered by TVA — boiling water reactors — has been around for decades. Indeed, the utility's 50-year-old Browns Ferry plant in Alabama is powered by three boiling water reactors.

Jeff Smith — who served as interim ORNL director after 21 years as the lab's chief operating officer and who also served on the TVA board — said TVA is wise to pursue a proven technology, noting that cost is especially important to the utility.

"The Tennessee Valley Authority Act of 1933 says that TVA is obligated to provide power as low as reasonably achievable in terms of rates. When I sat on the TVA Board, that's something you thought about every time you got together.

"So, the TVA approach is, we're going to use an existing design that's been proven. We're going to use existing fuel that's already licensed. And we're going to concentrate on controlling costs by going at it with a small design, a smaller plant."

If the project succeeds, he said, that success could accelerate the industry regionwide.

"If they can get that done, that creates a tremendous center of gravity around new nuclear that I think will bring additional companies and economic activity to the state of Tennessee and East Tennessee in particular."

The project, which is still in the planning phase, has a way to go, Boerschig said. The Nuclear Regulatory Commission granted TVA an early site permit in late 2019, and in 2022 the TVA board OK'd up to \$200 million for evaluation of the technology and establishment of a New Nuclear Program. TVA will likely submit a construction permit to the NRC in early to mid-2025.

"It's about a three-year review process," Boerschig said. "The board would have to approve going to the project phase. During the project phase the NRC would review our construction permit, and we would complete the standard and site-specific design and prepare for construction."

“Another possibility is to remain in the planning phase for the NRC construction permit application review and standard-design completion, then seek project approval for site-specific engineering and preconstruction work. We would have to go to the board again for construction phase approval with our final cost and schedule estimates for the first plant, demonstrate all our planning is rigorous and complete, discuss the economic viability of building multiple reactors, and seek TVA board approval to begin construction.”

Over the entire process, he said, it will be a decade or more before reactors would be generating electricity at the site.

Bringing fusion to East Tennessee

Type One Energy is the third entity developing a new platform in the region. But unlike the Kairos and TVA projects, Infinity One will be a fusion device, fusing the nuclei of atoms together rather than splitting them apart.

Infinity One will be located 20 miles east of TVA’s Clinch River location and will occupy a portion of the utility’s coal-burning Bull Run Fossil Plant, which was retired at the end of 2023.

Like the Kairos project, it will not produce electricity. Rather, it will be a prototype stellarator, a device that uses external magnets to confine a hydrogen plasma in the shape of a twisted donut or a bicycle tire. Stellarators were conceived more than 70 years ago, and the first dates back to 1953.

The project was announced in February 2024 by the company and Governor Lee. Besides locating the reactor itself, Type One moved its headquarters to Oak Ridge.

According to Matt Miles, the company’s senior vice president for marketing and external affairs, the company found the area attractive both because of a highly trained workforce — which he attributes to ORNL and the nearby Y-12 National Security Complex — and because of the support Type One has found from the lab, TVA, the state and DOE. He also pointed to the fusion expertise found in the region, especially at ORNL, which hosts both a Fusion Energy Division and the U.S. headquarters for the international ITER fusion device being built in France.

Miles noted that the company has deep relationships with ORNL. Company co-founder and chief science officer John Canik spent nearly 16 years at the lab, and Bradley Nelson, its vice president of engineering, was chief engineer for US ITER.

The technology has leaped forward in recent years, Miles said, pointing to more recent stellarators in Germany and at the University of Wisconsin, Madison. He pointed also to a 2022 experiment at the National Ignition Facility at Lawrence Livermore National

Laboratory in which a fusion reaction created more energy than required for the laser light that induced it.

“With the advances in additive manufacturing techniques and the advances that we now have in high-performance computing, it allows us to model things to a degree of fidelity that we couldn’t before,” he said. “The success of the HSX optimized stellarator [at UW] and then the W7X [in Germany], the ability of the NIF machine to get a burning plasma — not once, not twice, but now three times out in California — this gives us a degree of confidence that says the foundational science is proven for fusion.”

Because TVA is a federal entity, he said, the site will have to be reviewed under the National Environmental Policy Act. If all goes well, the company hopes to start construction in 2025 and begin operating Infinity One in 2028.

Looking to the future

Given the region’s strengths — and assuming the nuclear industry continues to gain traction — it’s likely that many more businesses will find their way to the Oak Ridge area and Tennessee. And if state and regional leaders have their way, the state will become an international focal point for nuclear technology and business.

“We believe it has the potential to be the largest nuclear hub in the U.S., if not the world,” said the East Tennessee Economic Council’s Boatner.

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