Tennessee Nuclear Energy Advisory Council

Final Report and Recommendations for Governor Bill Lee, Lt. Governor Randy McNally and Speaker Cameron Sexton

October 31, 2024

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT & CONSERVATION
NASHVILLE, TENNESSEE 37243

BILL LEE
GOVERNOR

DAVID W. SALYERS, P.E.
COMMISSIONER

October 31, 2024

Honorable Bill Lee
Governor, State of Tennessee
Tennessee State Capitol
Nashville, TN 37243

Sen. Randy McNally
Lt. Governor and Speaker of the Senate
425 Rep. John Lewis Way N.
Cordell Hull Bldg., Suite 700
Nashville, TN 37243

Rep. Cameron Sexton
Speaker of the House of Representatives
425 Rep. John Lewis Way N.
Cordell Hull Bldg., Suite 600
Nashville, TN 37243

RE: Tennessee Nuclear Energy Advisory Council Final Report & Recommendations

Dear Gov. Lee, Lt. Gov McNally, and Speaker Sexton:

On behalf of the Tennessee Nuclear Energy Advisory Council, I'm pleased to submit the council's Final Report and Recommendations ("Report") for your review.

This report was produced at the direction of Gov. Lee's Executive Order 101 and reflects the work of the council over the past 15 months. I commend the commitment and engagement of council members as they used their knowledge, expertise, and experience to identify strategies and working recommendations for your consideration. The nuclear industry is moving through a dynamic period, so this document features timely insights and guidance for Tennessee regarding nuclear energy and supply chain advancement.

This report identified five areas and opportunities in this moment as Tennessee seeks to accelerate deployment of reliable, resilient, dispatchable, clean nuclear energy to meet our state's increasing power demand and promote economic growth, prosperity, and opportunity:

1. **Addressing First-Of-A-Kind (FOAK) Cost for Initial Small Modular Reactor Deployment**
2. **Growing a Strong Nuclear Supply Chain**
3. **Coordinating and Enhancing Nuclear Workforce Development**
4. **Regulatory Responsiveness**
5. **Coalition Building**

The council organized its recommendations for the Governor's Office and General Assembly around these five opportunities. I trust this report, its accompanying recommendations and the diligent work of the council contributes to moving Tennessee toward maximizing our leadership position. I welcome your questions, feedback, and follow up on this report.

Thank you for your leadership on these meaningful matters for Tennessee.

Sincerely,

David W. Salyers, P.E.
Chairman, Tennessee Nuclear Energy Advisory Council

cc: Rep. Clark Boyd, District 46, TN Nuclear Energy Advisory Council Member
Brandon Gibson, Chief Operating Officer, State of Tennessee
Sen. Ken Yager, District 12, TN Nuclear Energy Advisory Council Member
TN Nuclear Energy Advisory Council Members

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Executive Summary

Tennessee Governor Bill Lee signed Executive Order 101 on May 16, 2023, establishing the Tennessee Nuclear Energy Advisory Council (Council) to provide recommendations that would accelerate the development of Tennessee's nuclear energy ecosystem for the betterment of Tennessee and the nation.

Domestic and global events over the past five years have created a resurgence in interest and activity in the nuclear sector, and Tennessee is uniquely positioned as the nation's leader in advancing nuclear energy technology and ecosystem. Starting with the Manhattan Project that helped bring an end to World War II, then providing the materials that helped win the Cold War and continuing today with pioneering research and development in the peaceful use of nuclear technology, Tennessee has led the nation's nuclear progress and continues to do so today.

No other state has such a broad, multi-sector inventory of assets and capabilities to advance, develop, and deploy nuclear technology. Today, Tennessee is home to our country's:

- largest multi-disciplinary U.S. Department of Energy (DOE) laboratory, Oak Ridge National Laboratory (ORNL), that hosts a variety of world-class nuclear capabilities, including high performance computing, advanced manufacturing, and radioisotopes production;
- enriched uranium processing and storage, housed at the Y-12 National Nuclear Security complex in state-of-the-art facilities that underpin our nation's nuclear deterrent;
- largest public power utility, the Tennessee Valley Authority (TVA), which operates our nation's fourth-largest commercial nuclear reactor power production fleet;
- largest brownfield cleanup and land transfer system; and
- first Department of Nuclear Engineering, established at the University of Tennessee in 1957 and still internationally recognized for excellence in research and teaching. One of the largest and finest in the nation.

These entities, enabled or complemented by federal investments and aided by the successful cleanup and land transfer of Oak Ridge's Cold War legacy, have now attracted more than 200 private sector companies operating in the nuclear space to Tennessee.

Since the Council was established, our state's private sector momentum in nuclear continues to grow:

- **Kairos Power** has been granted an NRC license to begin construction on a low-power demonstration reactor and just announced a partnership with Google that "represents the first corporate agreement for multiple deployments of a single advanced reactor design in the United States."

- **X-energy's TRISO-X** subsidiary is building the first commercial advanced reactor fuel fabrication facility in North America, and X-energy just announced a Series C-1 financing round of approximately $500 million anchored by Amazon.
- **Type One Energy** selected Tennessee and is partnering with TVA and ORNL to construct Infinity One, the world's most advanced stellarator, which will allow verification of essential elements of Type One's proposed fusion pilot plant.
- **Orano USA** announced in September the selection of Oak Ridge as its preferred site to construct a multi-billion-dollar, state-of-the-art centrifuge uranium enrichment facility, which will be the largest in the U.S. once completed.

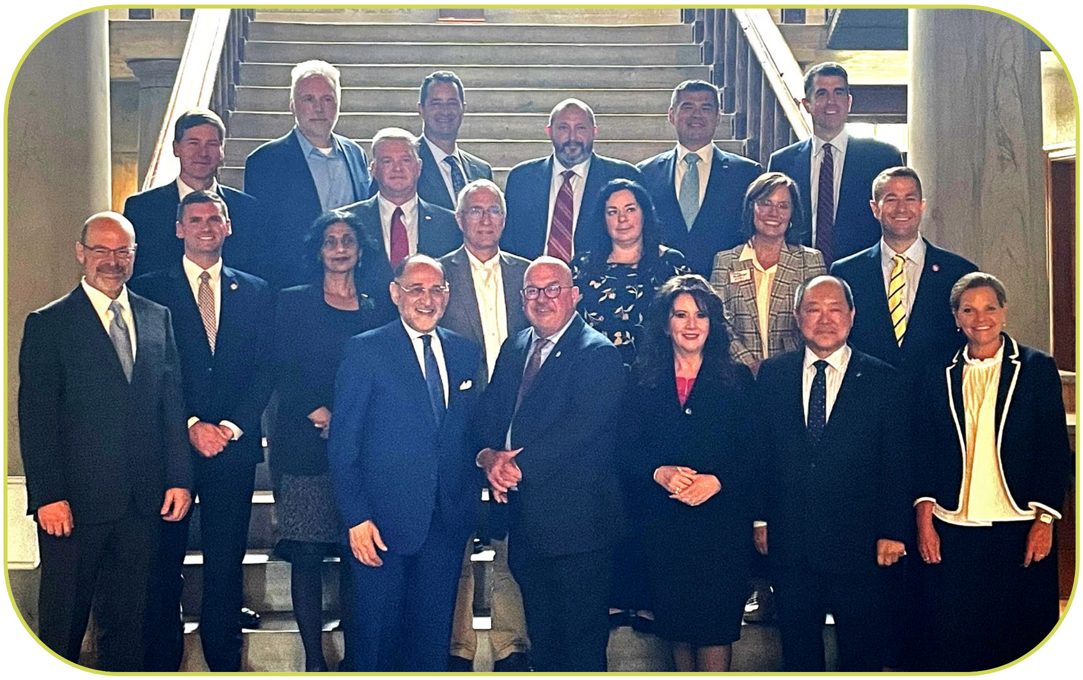
The Council did not need to contemplate creating a nuclear ecosystem from scratch. Tennessee already has the most robust and diverse set of capabilities in the nation. The Council focused on leveraging that advantage by identifying ways to accelerate the generation of reliable, resilient, safe, and clean power to meet increasing electricity demand and support the growth of a nuclear ecosystem and prosperous economy for generations to come.

The Council embraced Governor Lee's challenge: "What long-view decisions can we make or actions can we take today that will make Tennesseans in a quarter century say, 'We're better now because they did that back in 2025'?" This Report & Recommendations are designed to provide a roadmap of options and opportunities for positive generational impact by providing power and benefit to Tennessee, our region, and the nation. The recommendations address five topics:

1. The private sector, federal government, state governments, and traditional utilities are making unprecedented commitments to move new nuclear forward. Tennessee must explore nontraditional financial mechanisms to support TVA's effort to deploy a First-of-a-Kind Small Modular Reactor at the Clinch River Site.
2. The State should strengthen nuclear industry incentives to attract additional supply chain assets and companies in support of the nuclear ecosystem.
3. A holistic, integrated approach to workforce development, training, and education to provide sufficient numbers of new workers is necessary for an expanding nuclear industry.
4. Tennessee is a "business friendly" state, but there are opportunities to further improve the regulatory environment around fusion energy.
5. No single entity can bring new nuclear to life. Partnerships and coalitions will be essential to the successful deployment of new nuclear at scale.

Introduction

In May 2023, Governor Bill Lee established the Tennessee Nuclear Energy Advisory Council through Executive Order 101, tasking the Council with advancing Tennessee's nuclear leadership and expanding its nuclear energy ecosystem. The Council was established with key stakeholders from various sectors, including industry, academia, and government, to recommend legislative, policy, and budgetary actions to promote investment in nuclear innovation. List of Council members is attached in the Appendix A. As part of this initiative, the Council was instructed to deliver a comprehensive report to the Governor and legislative leaders by October 31, 2024, outlining strategies for Tennessee's continued leadership in nuclear energy.



Members of the Tennessee Nuclear Energy Advisory Council.

The Council provided a preliminary report in December 2023 suggesting that the State of Tennessee should focus on two broad strategies to secure the benefits of nuclear energy and associated ecosystem.

Broad Strategy #1: Advance New Nuclear and the Clinch River Nuclear Site

The State should partner with the TVA and other states in the TVA service area to advance new nuclear generally, and specifically to advance the Clinch River Nuclear Small Modular Reactor (CRN SMR) project.

Broad Strategy #2: Build the Nuclear Workforce and Supply Chain

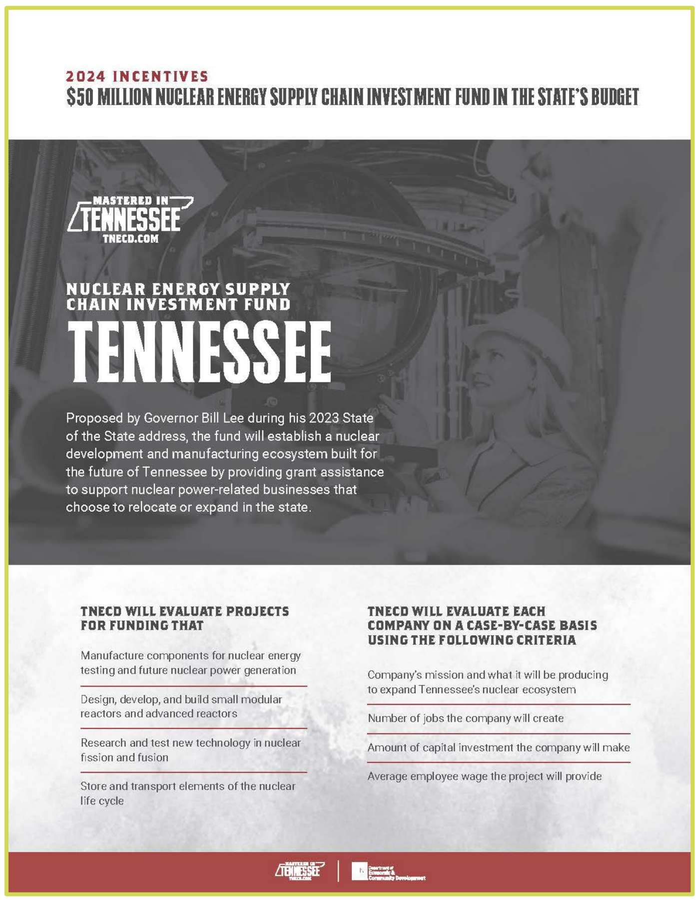
Tennessee should position itself as the obvious choice for companies that will make up the new nuclear supply chain, regardless of where new nuclear power is ultimately deployed. A workforce trained to work in the nuclear sector can underpin growth in related nuclear industries such as fusion energy and radiopharmaceuticals.

Since the delivery of the Preliminary Report, the Council organized its efforts around these two broad strategies and worked with numerous stakeholders to develop insights and ultimately a set of recommendations that will increase Tennessee's momentum to advance nuclear energy as a critical resource to power the state's economy.

The Council gathered business insights through an industry-wide survey, audience polling at the annual Nuclear Opportunities Workshop held by the East Tennessee Economic Council (ETEC), and meetings with industry partners. The Council's *Nuclear Business & Regulatory Survey – Insights from the Nuclear Community* is attached in the Appendix. These insights revealed:

- The Tennessee Nuclear Energy Supply Chain Investment Fund has already proven successful in attracting nuclear-related investments.
- Tennessee already has a robust ecosystem of nuclear businesses and organizations that foster innovation and development in the sector.
- Tennessee's population is largely supportive of nuclear energy, a key advantage for future development.

The balance of this report describes the analysis, key findings, and associated recommendations the Council put forth for consideration by the leadership of Tennessee state government.



TNECD's Nuclear Energy Supply Chain Investment Fund solicitation.

The Council's recommendations cover five topical areas that will reinforce Tennessee's leadership role in nuclear and, more importantly, will result in the deployment of baseload carbon-free energy and a vibrant nuclear ecosystem that will be a key contributor to the state's overall economy and underpin Tennessee's future economic growth.

Before presenting the Council's body of work, however, it is important to note that one overarching conclusion has shaped the Council's perspectives on much of what follows.

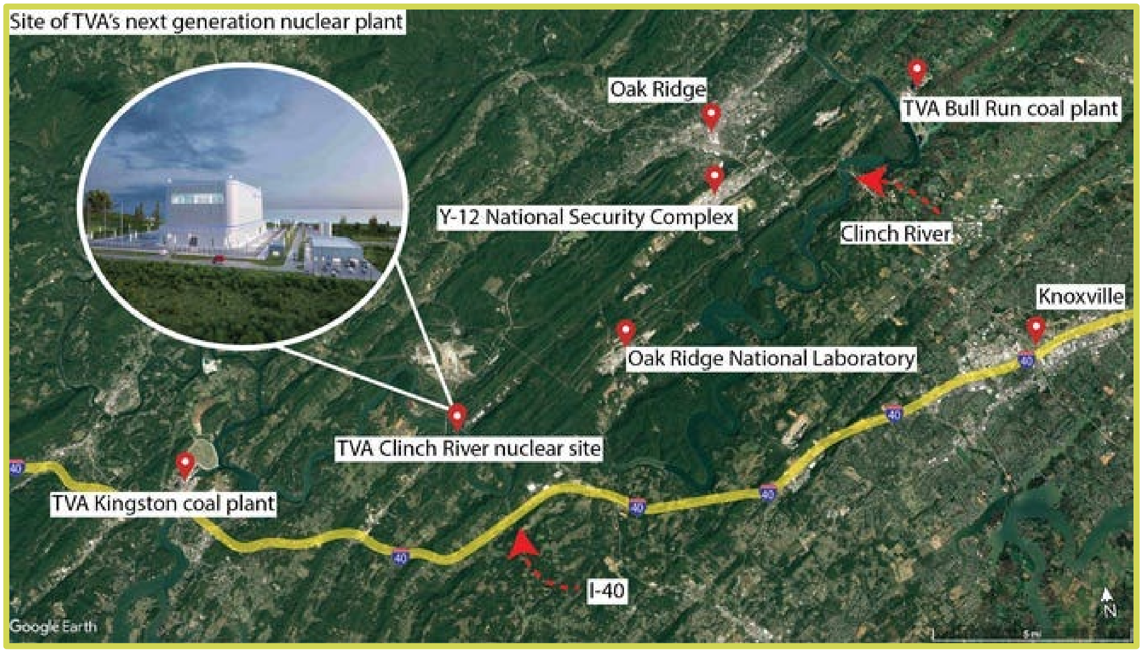
Recent years have brought a remarkable shift toward nuclear power becoming a key part of our nation's future energy strategy. However, as most of the U.S. nuclear reactor fleet was constructed more than 30 years ago, there is still considerable debate regarding which nuclear technology will break the hiatus in widescale nuclear deployment and provide the best chance to address the single biggest issue facing new nuclear, i.e. the cost of deployment.

With direction and strong support from Congress, the U.S. Department of Energy (DOE) has made significant investments in advanced reactor designs, but these technologies are still immature and have not advanced to the point of commercial deployment. NuScale, creator of an advanced reactor concept, was heavily funded by DOE but recently canceled its project due to the inability to maintain utility subscribers for its technology.

Other advanced designs are still moving forward, such as the Natrium reactor design offered by TerraPower. Bill Gates, TerraPower founder, has started non-nuclear construction of a liquid sodium testing facility in Kemmerer, Wyoming, with aspirations of having an operational reactor by 2030.

The U.S. Nuclear Regulatory Commission (NRC) recognizes the challenges in licensing new technology and has issued new guidance documents to facilitate the licensing process for non-light water reactor designs. The guidance is expected to significantly reduce the regulatory uncertainty for new reactor concepts, but that aspiration is unproven.

Southern Company's recent deployment of new nuclear at the Vogtle site in Georgia was plagued with cost and schedule delays. Its Westinghouse AP1000 design did not depart from traditional pressurized reactor designs, although it had several safety-related upgrades. Vogtle reactors are similar in scale and complexity to the existing commercial fleet. Unfortunately, cost overruns and schedule delays only underscored the difficulty associated with deploying new nuclear. A 2014 study[1] examined 180 nuclear power projects around the world and found 175 exceeded the initial budget by an average of 117% by the time they were completed.



Site of proposed TVA's Clinch River Nuclear Small Modular Reactor site

Rather than attempting to pioneer a Generation IV nuclear reactor technology, with associated challenges in licensing and fuel supply, TVA is evaluating a traditional reactor technology (known as a boiling water reactor) in a smaller size designed by GE Hitachi for potential, future deployment. In addition, TVA's approach leverages a site for which the NRC has already approved an Early Site Permit, meaning that it is suitable for small modular reactors, and the GE Hitachi reactor design uses a nuclear fuel that is already licensed. These two factors alone remove considerable risk (and presumably cost) for the potential, future deployment of a small modular reactor at their Clinch River Nuclear site.

In addition, TVA is collaborating with the Ontario Power Generation (OPG) in Canada and Synthos Green Energy of Poland to share in the upfront design costs. TVA will benefit from being a "close follower" to the deployment of the first GE Hitachi SMR by OPG. The Council believes TVA's approach is the lowest risk approach to deploying new nuclear and provides the shortest possible time frame to not only deploy a first reactor but subsequent reactors by the end of the next decade, at costs the market can bear.

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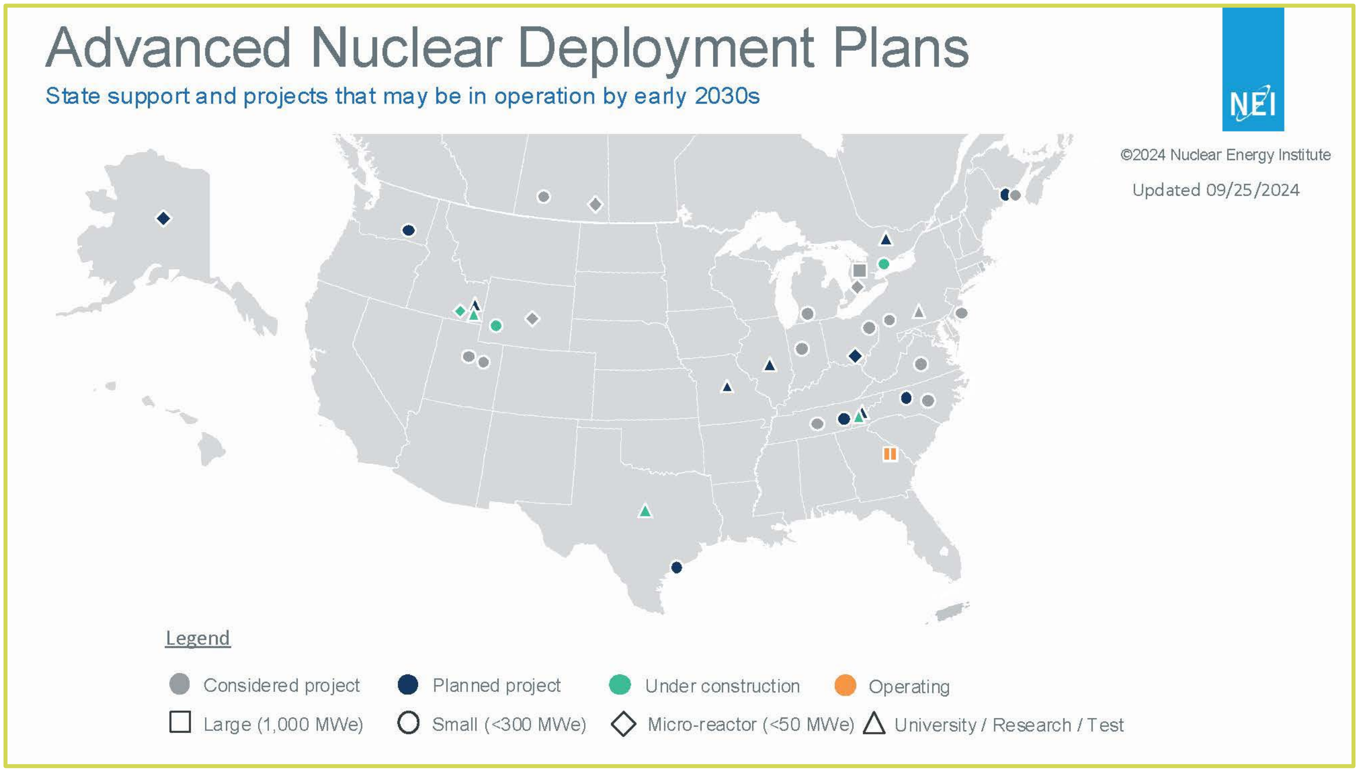
Tennessee is rapidly becoming the epicenter for new nuclear. The Nuclear Energy Institute (NEI) has produced a national map illustrating advanced nuclear deployment plans for each state and reflecting state-level activity and support for advanced nuclear that may be in operation by early 2030s. Tennessee is the leading state for potential advanced nuclear deployment.



Nuclear Energy Institute's Map of State Action and Advanced Nuclear Projects.

- Green triangle reflects Kairos Hermes test reactor under construction
- Blue triangle reflects planned Kairos Hermes 2 test reactor
- Blue circle reflects planned Clinch River Nuclear SMR(s)
- Gray circle in middle TN reflects TVA IRP consideration for reactors beyond CRN Clinch River

TVA's potential, future deployment of a small modular reactor at its Clinch River Nuclear site is the best and lowest risk approach to deploying domestic new nuclear able to deliver power to the grid at scale over the near term. With the optimal support, TVA provides the shortest possible time frame to not only deploy the first reactor but subsequent reactors by the end of the next decade, at costs the market can bear.

"TVA has always leaned in on difficult things."

- U.S. Department of Energy Secretary Jennifer Granholm, Dec. 5, 2023

Secretary of Energy Jennifer Granholm speaking with Bob Deacy, TVA SVP Clinch River Nuclear Project, and Jeff Lyash, TVA President and CEO at the Clinch River Nuclear SMR Site on Dec. 5, 2023.

TVA and its employees, including Don Moul, an officer of TVA, participated in the Council to provide information on issues related to the state of the nuclear industry, including factual information about TVA's nuclear program and the Clinch River Project, as well as insights to the Council based on Mr. Moul's professional experience in the nuclear industry. TVA and its employees are bound by federal ethics laws and policies concerning endorsements and lobbying, and TVA's and its employees' participation in the report should not be considered to be an endorsement of, or lobbying in favor of, any particular recommendations. TVA and Mr. Moul have recused themselves from the recommendations contained in the Council's Report.

Analysis and Recommendations

Section 1: Addressing First-of-A-Kind Costs

First-of-a-kind (FOAK)[2] costs are the biggest challenge for domestic deployment of any next-generation nuclear project.

1.1 Analysis

There has been a remarkable shift in the past five years resulting in considerable support for more nuclear power being part of our nation's future energy strategy. However, as most of the U.S. nuclear reactor fleet was constructed more than 30 years ago, there is still considerable debate regarding which nuclear technology will break the stubborn pause seen in widescale nuclear deployment and provide the best chance of dealing with the single biggest issue facing new nuclear, i.e. cost of deployment.

Rather than pursuing a Generation IV nuclear reactor design with associated challenges in licensing, fuel supply, and supply chain, TVA is taking a different approach to deployment of potential, future nuclear capacity. TVA is evaluating traditional reactor technology (a boiling water reactor design common in the existing U.S. commercial fleet) at both the 1000MW scale typical in the existing fleet and a smaller size 300MW for potential, future deployment. GE Hitachi is the designer of the small modular reactor TVA is evaluating. TVA's approach leverages a site for which the NRC has already approved an Early Site Permit, meaning that it is suitable for small modular reactors, and the GE Hitachi reactor design uses a nuclear fuel that is already licensed. These two factors alone remove considerable risk (and presumably cost) for the potential, future deployment of a small modular reactor at the TVA Clinch River Nuclear site. In addition, TVA is collaborating with OPG in Canada and Synthos Green Energy of Poland to share in the upfront design costs. TVA will also benefit from being a "close follower" to the deployment of the first GE Hitachi SMR in by OPG.

Even with the advantages of a known technology, existing fuel, etc., there are still significant FOAK costs that make TVA's potential, future SMR deployment challenging. It is further noted that in TVA's

[2] First-of-a-Kind, or FOAK, refers to the first model of a new generation, where costs are expected to be significantly higher than subsequent commercialized models. Commercialized future models are referred to as Nth-of-a-kind, or NOAK. Experts suggest NOAK costs should be achievable after the fifth deployment of the same reactor.

case, as a governmental entity charged with a mandate to keep consumer electric rates “as low as achievable,” covering FOAK costs without putting upward pressure on rates is nearly impossible.

Nuclear, by nature, is more capital intensive to bring into the generation mix, but the *longer-term value of nuclear*—from a financial, grid management, length-of-service, and carbon-impact perspectives—underpins the Council’s opinion that solving the FOAK problem is worth the effort and critical to deployment of new nuclear under TVA.

While the Council believes TVA is making every effort to reduce these costs to as low as achievable, these costs will be non-trivial, and TVA is unlikely to pass these FOAK costs to the TVA rate payers. In the end, FOAK costs will likely present the most challenging barrier to decisions by the TVA Board to proceed with construction of the first SMR at Clinch River.

Therefore, the Council spent considerable time working with TVA and others to first understand the drivers behind FOAK costs, and then to develop ideas on how they might be addressed.

1.2 Conclusions and Recommendations

Conclusion 1-A:

Because the benefits of leadership and success with the future, potential deployment of an SMR at the Clinch River Nuclear site project will extend far beyond the Tennessee Valley, the FOAK costs of the project must be equitably supported by outside investment over and above support from TVA ratepayers.

Conclusion 1-B:

The TVA Act mandates “rates as low as achievable” and imposes a $30B debt cap that will necessarily drive TVA to consider non-traditional mechanisms to fund FOAK costs.

The private sector, federal government, state governments, and traditional utilities are making unprecedented commitments to move new nuclear forward. Tennessee must explore nontraditional mechanisms to support TVA. While the addition of reliable, resilient, safe, clean baseload power for 40 years or more and annual generation sales realized are of primary importance, there are other benefits for Tennessee and the region from first SMR deployment:

- UT Baker School of Public Policy's Economic Impact Assessment (EIA) estimates an SMR (300 MW) deployed in Tennessee would generate $1.4 billion in construction spending directly sourced from within the state. Netting out employment benefits and taxes on worker payroll, $1 billion in spending would spread through supply chains and create a multiplying ripple effect across Tennessee. This would facilitate 16,440 new jobs (or 1,827 jobs per year) and increase the total production of goods and services in the state by $1.6 billion, or $175.2 million annually. Baker School SMR EIA is attached in the Appendix C.
- Strategic value of building the first SMR would address FOAK costs and set the stage for ideal cost reduction, up to 40% per unit, as additional SMRs are built.
- Supply chain opportunities for Tier 1-3 suppliers locating or expanding in Tennessee for manufacturing or fabricating components for SMR deployment in Tennessee. EIA offers guidance in approaching GE-Hitachi and TVA to discuss opportunities and expectations for growing in-state spending on goods and services during construction of an SMR in Tennessee as well as any subsequent units.
- Potential for premium pricing schedule or agreements for SMRs' carbon-free power from particular purchasers (e.g., data centers, hyperscalers, etc.).
- Effects of first and future SMRs attracting talent, R&D/tech transfer, wraparound knowledge, capital, and community support to benefit the region's nuclear ecosystem, further demonstrating that Tennessee is a hub for nuclear development, manufacturing, and deployment.

Recommendation 1.1:

The State should actively collaborate, coordinate, and assist TVA in efforts to secure federal funding to support FOAK by demonstrating the State's tremendous support and investment in new nuclear and deployment of SMR technology at the Clinch River Nuclear site.

Recommendation 1.2:

The State should consider additional investments in new nuclear and particularly in direct support of TVA's consideration of the potential, future deployment of an SMR at the Clinch River Nuclear site.

TVA pays each state in the TVA region a "payment in lieu of taxes" (PILOT) that is based on 5% of its prior-year gross proceeds from power sales (excluding direct sales to federal agencies). Each state's allocated amount is based both on revenue from power sold by TVA in each state and on the value of TVA power property in that state. Given TVA's ongoing efforts to build new generation capability and the projected increases in overall power sales, Tennessee expects PILOT payments to increase in the near term.

Recommendation 1.3:

The State should work with TVA to identify private investment capital aligned with TVA's and the State's long-term interests.

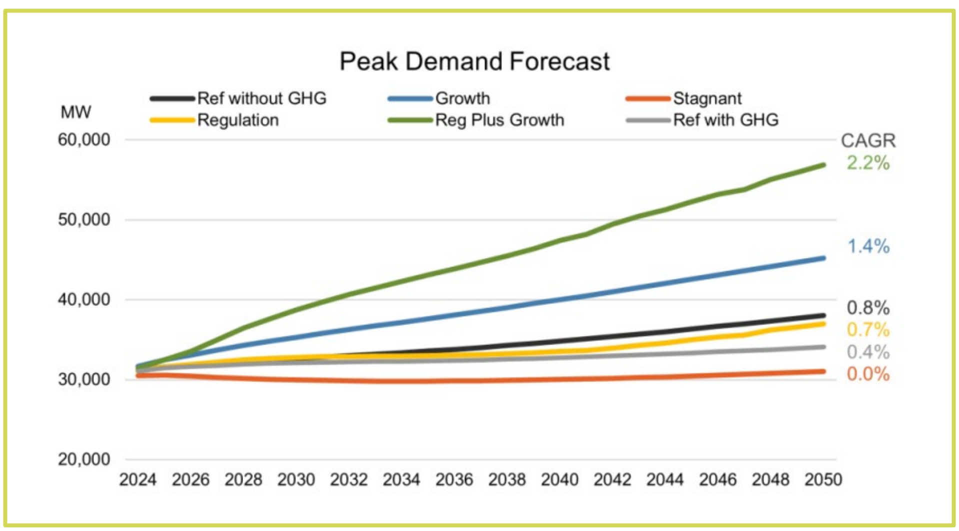
Significant private investment capital exists in the market looking for opportunities to advance the deployment of new technologies that reduce carbon emissions. While co-mingling private investment with traditional TVA financing on a single capital project will be challenging, the opportunity is significant enough to warrant our collective best efforts to find a path forward.

Section 2: Growing a Strong Supply Chain

The supply chain necessary to support broad scale deployment of new nuclear is still in the formative stages. Tennessee already has a strong network of supply chain activity, but there is tremendous additional opportunity for the State to expand on its leadership and presence in this area.

2.1 Analysis

While the Council's work outlined in Section 1 focused exclusively on supporting TVA's efforts in evaluating the potential, future deployment of an SMR at its Clinch River Nuclear site, the Council takes a much broader view of the opportunities for Tennessee in the supply chain supporting new nuclear.



TVA IRP 2025 shows likely peak demand on system could nearly double by 2050

Numerous studies conclude that demand for nuclear power will rise significantly, both in the U.S. and globally, over the next three decades. This expansion will take many forms, including small modular reactors already discussed, but larger reactors consistent with our existing fleet are envisioned as well. A new class of advanced reactors (specifically called Generation IV) will require different nuclear fuel types and uranium enrichment levels. Recent investments in fusion power suggest its technology will start to impact supply chains sooner than previously expected, too.

While commercial nuclear power is almost a singular focus when "new nuclear" is discussed, U.S. national science, defense and cleanup needs are also creating new demand signals in the nuclear supply chain. Of note here is the decision by the DOE to complete a study on deploying a uranium enrichment centrifuge pilot plant to support the National Nuclear Security Administration's (NNSA) mission requirements for its defense programs. The year-long engineering study will inform DOE/NNSA's acquisition approach for demonstrating Domestic Uranium Enrichment Centrifuge Experiment (DUECE) technology in a pilot plant at DOE's Oak Ridge National Laboratory.

Collectively this demand for "new nuclear" will impact the supply chains that exist today, which largely are aligned with a well-known, proven technology, i.e. the existing commercial reactor fleet.

This points to opportunity for Tennessee, especially given the existing concentration of entities engaged in the nuclear supply chain.

2.2 Conclusions and Recommendations

Conclusion 2-A:

The State should strengthen incentives that are relevant to the nuclear industry to attract additional supply chain assets.

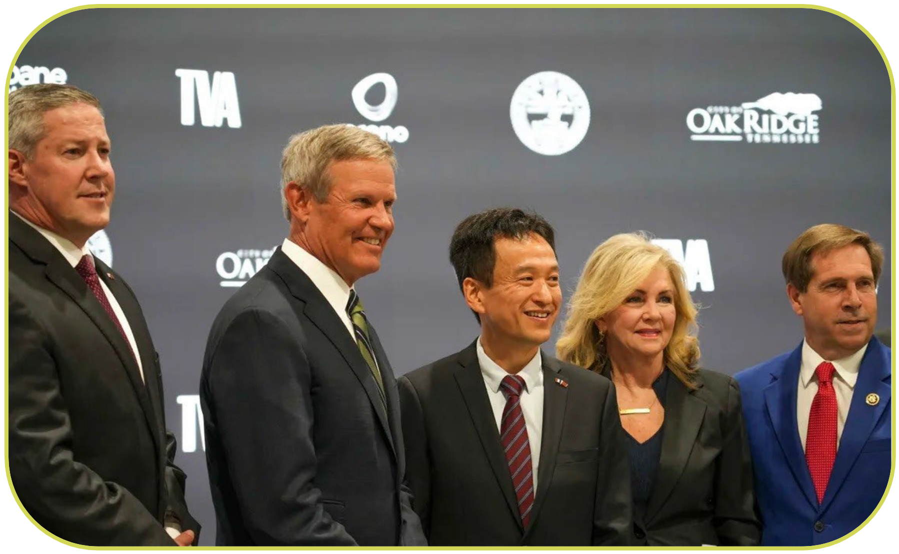
The Tennessee Nuclear Energy Supply Chain Investment Fund (the Fund) has already been a factor in recruiting new businesses. Type One Energy was the first business to utilize the Fund and Orano USA was the second.

Recommendation 2-A-1:

Evaluate, sustain, and grow the Tennessee Nuclear Energy Supply Chain Investment Fund administered by the Tennessee Department of Economic & Community Development (TNECD).

a. **Evaluate traditional incentive standards to prioritize and potentially create a framework to support strategically positioned companies that advance growth in new nuclear, including support for small and existing Tennessee companies.**
b. **Evaluate how best to partner with venture capital and private equity to invest and advance new nuclear.**
c. **Use the Fund to support consultation services for companies new to working to the Nuclear Quality Assurance (NQA-1) standard.**
d. **Conduct an annual evaluation of the Fund to ensure its successful use and ability to adapt to the evolving needs of the nuclear industry.**

The availability of resources to provide creative incentives has already proven to be an important part of recruiting new companies to Tennessee. Non-traditional incentives will be needed to fit the needs of the nuclear industry.



Roane County Mayor Wade Creswell, Governor Lee, Orano USA CEO Jean-Luc Palayer, Sen. Marsha Blackburn, and Cong. Chuck Fleischmann at Orano USA announcement on Sept. 4, 2024

Recommendation 2-A-2:

Establish a dedicated jobs tax credit multiplier for nuclear energy projects under the "Special Provisions" section of T.C.A. § 67-4-2109 to provide nuclear companies with higher credit when they create jobs and make significant capital investments in Tennessee.

Under Tennessee's franchise and excise tax laws, companies can receive a jobs tax credit for creating new jobs and making capital investments. The credit incentivizes businesses to expand operations and invest in Tennessee, with multipliers based on the type of industry and level of capital investment. Nuclear energy projects—which involve high capital costs and substantial job creation—are not currently offered a specific multiplier.

Recommendation 2-A-3:

Amend T.C.A. § 67-4-2004 to include nuclear energy production facilities as Certified Green Energy Production Facilities, alongside geothermal, hydrogen, solar, and wind energy producers. This amendment would allow nuclear energy producers to qualify for tax credits under § T.C.A. 67-6-346, providing them with financial incentives like those available for renewable energy sources.

T.C.A. **§** 67-4-2004 defines geothermal, hydrogen, solar, and wind energy production facilities as Certified Green Energy Production Facilities, making them eligible for state tax credits under T.C.A. 67-6-346. Including nuclear energy production facilities in this list would acknowledge the role of nuclear power in providing clean, reliable energy, and provide a financial boost to Tennessee's nuclear industry by granting them the same tax benefits as other renewable energy sectors.

Conclusion 2-B:

TVA's potential, future deployment of an SMR at its Clinch River Nuclear site presents several specific opportunities to build supply chain capacity in Tennessee.

TVA's CEO Jeff Lyash has repeatedly stated in public that he is not interested in building a single SMR. He sees the need for 20 or more SMRs to meet the needs of the Tennessee Valley. Couple this demand with other users of this technology (OPG and Synthos Green Energy are publicly committed to GE Hitachi's design), plus other U.S. utilities that could follow TVA's lead, and there could be considerable business generated in building components for the GE Hitachi SMR design. The top 5 new supply chain opportunities for SMR deployment in the Tennessee Valley are expected to be as follows:

- Reactor Pressure Vessel – manufacturing and fabrication
- Diaphragm Plate Steel Components (DPSC) manufacturing, fabrication and construction
- Reactor Building Excavation
- Residual Pressure Relief Isolation Valve – manufacturing and fabrication
- Isolation Condensers – manufacturing and fabrication

Recommendation 2-B-1:

TNECD should continue direct engagement with GE-Hitachi and TVA regarding supply-chain needs for the potential, future deployment of an SMR at the Clinch River Nuclear site to identify specific opportunities to fill supply chain opportunities via new business recruitment or expansion of existing companies.

The State may need to alter or develop new incentives to secure commitments for these companies to be domiciled in Tennessee.

Conclusion 2-C:

Ensuring the west end of Oak Ridge is carefully developed to support new nuclear and its supply chain will increase Tennessee's already strong competitive advantage.

Often called the Oak Ridge Corridor, it is difficult to draw discrete boundaries around what has become, as previously discussed, a center of mass regarding nuclear. The west end of Oak Ridge, including current and former DOE land, constitutes most of the physical footprint for the entities that built this legacy. Property in both Roane and Anderson counties may provide most of the acreage involved, but nuclear-related companies exist in neighboring counties such as Knox and Loudon. The area has immediate or close access to existing rail, barge, interstate, a business class airport at the western terminus, and a commercial airport at its eastern terminus.

Equally important, the communities surrounding this area offer strong support for businesses that have become the fabric of their livelihood. Communities such as Oak Ridge, Clinton, Kingston and others have provided generations of workers to support the numerous endeavors originating in the Corridor, and significant populations of workers from Knox County contribute to the Corridor's highly skilled workforce as well.

Recommendation 2-C-1:

The Governor should direct the TNECD Commissioner or designee to coordinate with the US Department of Energy, TVA, the Tennessee Department of Environment & Conservation (TDEC), Roane County, Anderson County, the City of Oak Ridge, and other stakeholders to ensure resources, area master planning, and available land are focused to be attractive to nuclear companies. A specific plan should be developed to inventory, prepare, and make available currently underutilized property in key areas.

The Council believes an expanding nuclear sector will bring more opportunities to attract entities engaged in the nuclear supply chain. Without dedicated areas for nuclear supply chain development and a coordinated approach to siting, Tennessee risks missing opportunities to attract key players in the nuclear industry. A strategic focus on preparing industrial areas specifically for nuclear supply chain businesses is prudent.

TDEC Commissioner David Salyers celebrates successful "cleanup to clean energy" on the Oak Ridge Reservation

Section 3: Coordinating and Enhancing Workforce Development

Access to a qualified workforce is a major factor when companies are deciding where to site new locations or operations.

3.1 Analysis

The Council maintained consistent communication, coordination with Governor's Office and identified opportunities to involve or connect with existing state government initiatives and activities to support nuclear workforce development priorities, including:

- Governor's Initiative in Vocation Education (GIVE 3.0) grants for Knoxville TCAT and Roane State Community College
- Apprenticeship Program with TN Department of Labor & Workforce Development
- National Research through ORNL and higher education assets and opportunities at University of Tennessee, Vanderbilt, Tennessee Tech and various TBR entities.

The Council also coordinated with TNECD and the TN Nuclear Energy & Supply Chain Fund to provide input and guidance on workforce opportunities associated with the Fund. When appropriate or requested, Council developed workforce related proposals for the Fund's consideration and action, including establishing nuclear minor at UT Tickle College of Engineering, investing in hands-on laboratory for new Nuclear Tech Program at Roane State Community College and supporting start-up costs for new B.S. in nuclear engineering at Tennessee Tech.

Governor Lee announces TN Nuclear Energy & Supply Chain Fund award to Tennessee Tech supporting launch of their new B.S. in Nuclear Engineering during Fall 2024.

Tennessee Nuclear Education

begins in kindergarten and goes through PhD programs

Colleges of Applied Technology (TCAT)

24 TCAT campuses with **70+** programs.

$2.4M in funding was provided by the Governor's Investment in Vocational Education grants for TCATs to support nuclear education of the skilled workforce.

Universities

The University of Tennessee (UT) hosts the largest Nuclear Engineering **PhD** program and the second-largest Nuclear Engineering undergraduate Bachelor of Science program. **$1M** in funding from the Nuclear Energy Fund supported the development of a Nuclear Engineering Minor for non-Nuclear Engineers.

Tennessee Tech University (Tech) launched a Bachelor of Science program in Nuclear Engineering in Fall 2024 with **$7M** in congressional support from Congressman John Rose and **$1.08M** from the Nuclear Energy Fund to ensure successful startup.

Community Colleges

3 community colleges offer nuclear degree programs: Chattanooga State, Pellissippi State, and Roane State.

Roane State Community College received **$450K** from the Nuclear Energy Fund, **$1.2M** from the U.S. Department of Labor, and **$200K** from Oak Ridge National Laboratory (ORNL) to support the start-up of its Nuclear Technology Program in Fall 2024.

= TCAT Locations

Vanderbilt hosts the Consortium for Risk Evaluation with Stakeholder Participation (CRESP), a multi-university project that aims to improve the scientific and technical basis for environmental management decisions around nuclear waste management, site selection, and community engagement.

Chattanooga State hosts the longest-running Nuclear Power Engineering Technology Program for TN community colleges in partnership with TVA.

ORNL hosts the Nuclear Energy Management School, which educates a global cohort of nuclear leaders.

A renowned hot-spot of nuclear research, the region hosts ORNL and the Tennessee Valley Authority Headquarters, and will one day host the nation's first small modular reactor.

Elementary School

Nuclear content is introduced in elementary school readings and activities.

$500K was invested from the Nuclear Energy Fund into nuclear related technical assistance, including teacher, and faculty workshops.

Middle School

Some nuclear technical training programs are available beginning in middle school and nuclear is included in science, technology, engineering, and math (STEM) days.

High School

High schools in the state offer technical training programs, and select schools are developing an energy career cluster to provide foundational energy knowledge, including a nuclear duel credit course that could be transferred to higher education institutions.

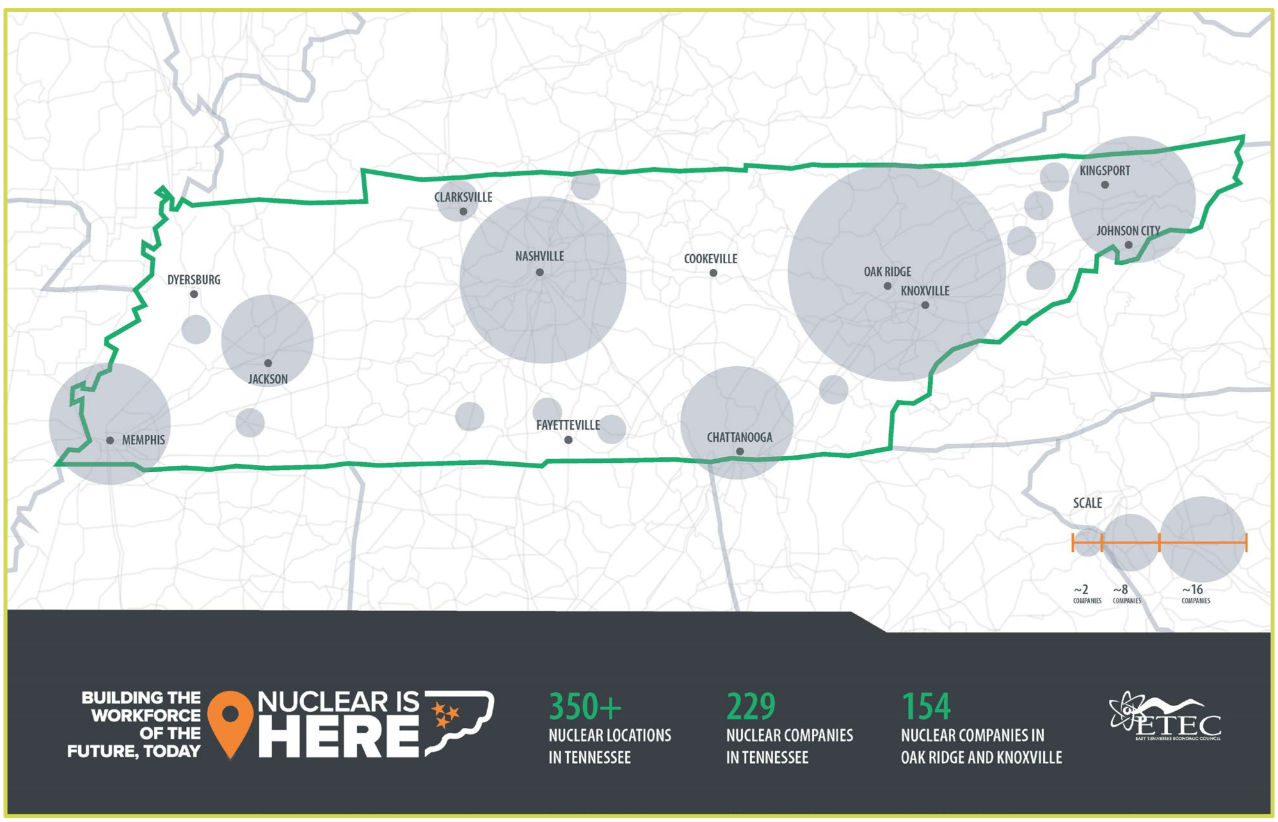
The Tennessee General Assembly approved the Nuclear Energy Fund in the 2023-2024 budget for $50 million, and an additional $10 million was appropriated in the 2024-2025 budget. The $60 million fund aims to expand the state's nuclear development and manufacturing ecosystem by providing grants and assistance to support nuclear power-related businesses and education and training programs across Tennessee.

Informational graphic on nuclear education initiatives in Tennessee

Tennessee's historic performance and current commitment to nuclear education is a strategic advantage for the state and region. However, present and future labor demand for nuclear energy and supply chain work exceeds even Tennessee's nation leading output. Prevailing and projected workforce needs for nuclear activities place a premium on ability of states to organize and deliver to meet them.

The Nuclear Energy Institute workforce report projects 236,000 workers will be needed to manufacture, construct, and operate advanced reactors through 2035, with that number increasing to approximately 376,000 workers by 2050.

Currently, more than 230 nuclear companies operate in Tennessee. Several are new to the state and plan major nuclear construction projects. Companies actively investing resources in the nuclear industry in the Oak Ridge area include Kairos Power, TRISO-X, Ultra Safe Nuclear, Type One Energy, and Orano, which recently announced the largest private investment in Tennessee history. These new companies, and several more in negotiations, will add to the workforce load of nuclear related professions as TVA continues to move toward potential construction and operation of an SMR.



ETEC mapped companies driving, working, and supporting nuclear activities across Tennessee.

TVA reports its $16B asset investment over the next three years increases its need for craft labor by more than 50 percent. Specific to the nuclear sector, TVA estimates a need for 1,200-1,500 construction workers to build an SMR and an average of 80-100 annual workers to maintain and operate it, with an additional 150-200 craft workers who would routinely perform outage work throughout the year. Competing external construction projects in the Southeast are noted as a risk for TVA obtaining this workforce.

There are multiple organizations responsible for different education programs. These organizations touch every demographic in the education pipeline, some with programs or initiatives specifically targeted at producing qualified workers for the nuclear industry. Nuclear content is being integrated into K-12 curricula, Tennessee Colleges of Applied Technology are investing in nuclear-specific career pathways, community colleges are delivering nuclear technology programs, and Tennessee's flagship university in Knoxville has the largest nuclear PhD program in the country. An inventory of nuclear education programs and initiatives is attached in Appendix D. Significant resources are already being committed to the training and education of workers qualified to enter the nuclear industry. The challenge is to coordinate and integrate delivery of various programs in a way that better matches output to demand.

3.2 Conclusions and Recommendations

Conclusion 3-A:

A holistic, integrated approach has not yet been implemented for training and educating the number of new workers needed for an expanding nuclear industry.

Several new programs are being deployed to fill important gaps in the education pipeline. To date, these programs have been pushed forward by the initiative of educational leaders.

Recommendation 3-A-1:

Launch a 3-year pilot for the Tennessee Nuclear Energy Workforce Center (T-NEWC), which will be administered by a third party.

The Council, in collaboration with Oak Ridge Associated Universities (ORAU), Global Action Platform (GAP) and TDLWD, has initiated a strategic effort to assess and improve the state's nuclear energy workforce development landscape. This initiative seeks to develop an integrated nuclear workforce enterprise in Tennessee addressing the need for inter-agency collaboration, resource sharing, and program mapping to bridge gaps in workforce development. Anchored by the T-NEWC concept, the plan aims to establish a coordinated approach, optimizing workforce alignment and positioning Tennessee as a leader in the nuclear industry. T-NEWC will be charged with coordinating and integration of relevant federal and state resources, educational entities, and industry representatives to produce tangible, measurable results and deliver more and better qualified workers matched to industry needs. The *Tennessee Nuclear Energy Workforce Center (T-NEWC) Proposal* is attached in Appendix E.

Demonstrating to companies interested in locating or expanding in Tennessee that a trained workforce is available is essential. A more robust effort to understand, manage, and communicate the workforce needs so appropriate institutions can respond will improve Tennessee's ability to commit to the availability of a trained workforce during recruitment efforts.

Section 4: Regulatory Responsiveness

Tennessee is a "business friendly" state, and there are opportunities to further improve the regulatory environment around nuclear.

4.1 Analysis

Regulation of the civil nuclear energy industry in the U.S. is distinctly different from regulation of much of the rest of the energy sector. The nuclear power industry is regulated under a centralized, federal approach through the NRC. However, nuclear plants must navigate more than just NRC regulations. States maintain authority over certain indirect aspects of nuclear power plant operations relevant to the environment. For example, states have authority over water permitting that can affect nuclear power facilities.

In addition, under the NRC Agreement State Program, state governments can sign agreements with the NRC to take over authority to license, conduct inspections and enforce safety regulations for certain radioactive materials. The State of Tennessee holds an agreement with the NRC under this program. This agreement applies to a limited scope of radioactive materials for industrial, medical and academic uses. Examples include byproduct materials like radioisotopes, source materials like uranium and thorium, and certain quantities of special nuclear materials. The NRC has recently determined that fusion power reactors will be regulated in a manner consistent with the regulation of nuclear materials. Since Tennessee is an Agreement State, this effectively delegates authority to regulate fusion power facilities to the State.

Tennessee's nuclear industry is diverse, encompassing not only energy production but supply chain activities, research and development, and medical isotope manufacturing. However, the State's current structure requires companies to navigate multiple agencies and programs, creating inefficiencies and potential delays in decision-making. The Council conducted a nuclear industry survey that indicated that businesses find this fragmented approach challenging, and many expressed the need for a single, coordinated office that provides guidance on both regulatory and economic matters.

With this context, the Council offers three recommendations that will help companies that wish to site nuclear-related operations in Tennessee, not just traditional nuclear fission power reactors but other types of power generation and industries such as isotope production as well.

4.2 Conclusions and Recommendations

Conclusion 4-A:

Tennessee's nuclear-related processes are managed by multiple agencies, each with its own scope of responsibility. This decentralized approach can lead to inefficiencies and gaps in regulatory oversight and inconsistencies in how nuclear companies are supported. There is no unified road-map that aligns Tennessee's regulatory, emergency preparedness, and workforce strategies with the needs of the nuclear industry.

As Tennessee continues to attract nuclear companies and expand its presence in nuclear energy, supply chain development, and medical isotope production, businesses have identified a need for more coordinated support from state government. Companies seeking to enter or expand in Tennessee's nuclear sector must navigate various agencies, regulatory processes, and economic incentives independently. A joint office or regulatory facilitation team would consolidate these efforts, simplifying interactions and providing more efficient, business-friendly support. A more coordinated, strategic approach could improve transparency and efficiency.

Recommendation 4-A-1:

Establish a Joint Office of Nuclear Advancement to formalize existing capabilities and serve as a collaboration between TNECD, TDEC, Tennessee Department of Labor & Workforce Development (TDLWD) and the Tennessee Emergency Management Agency (TEMA) to serve as a centralized hub and unified point of contact for the nuclear industry and stakeholders to engage the State for incentives and processes related to nuclear energy, supply chain, and medical isotopes.

This new entity would be a single point of contact for any company working through regulatory issues with the State, ensuring that the right resources are being applied to address regulatory issues efficiently.

Recommendation 4-A-2:

Direct the Joint Office of Nuclear Advancement to inventory nuclear-related processes for the purpose of creating a comprehensive strategic road map for the future of the nuclear industry in Tennessee.

This strategic roadmap would provide a basis for an annual report to State leadership demonstrating progress in addressing regulatory challenges and identifying recommendations for potential efficiencies in the State's regulatory approach.

Conclusion 4-B:

Tennessee has made strides in promoting fusion technology, but critical opportunities exist to improve the current public health and safety regulatory environment to handle the complexities of fusion energy.

Without a dedicated regulatory framework and more robust technical tools, fusion companies may face uncertainty and delays, hindering their ability to operate and grow in Tennessee. Given that Tennessee is an Agreement State with the NRC, the State has the authority to develop a fusion power regulatory approach. TDEC is the lead agency and is already working on this subject with other states.

Recommendation 4-B-1:

The Governor should continue support for the development of a comprehensive regulatory framework addressing fusion power. In addition, clear expectations for timing of that regulatory framework should be set and supported with appropriate resources.

Supporting the continued development of a fusion regulatory framework is essential for ensuring that Tennessee remains a top destination for fusion energy innovation. By providing a clear, consistent regulatory pathway, the State will foster business growth, attract leading companies, and ensure that fusion energy is developed safely and efficiently. This initiative will enhance Tennessee's reputation as a forward-thinking leader in the nuclear and energy sectors.

Staff from the Tennessee Department of Environment and Conservation's Division of Radiological Health with Type One Energy and TVA at the closed TVA Bull Run Fossil Plant site that will be location of Type One's potential fusion prototype machine.

Recommendation 4-B-2:

Develop robust technical tools to support regulatory oversight and decision making across the entire range of the State's activities related to nuclear and radiological health, e.g. dose calculations.

The use of computational tools for radiological dose calculations offers a prime example of expediting regulatory decision making. Today, regulatory staff use traditional hand calculation methods to determine radiological shielding requirements that ensure radiological doses are within acceptable limits. These calculations are laborious and difficult. With some investment, computer codes could be developed that would both expedite the process and provide higher confidence that the radiological environment has been bounded appropriately.

Section 5: Coalition Building

If Tennessee wants to see new nuclear deployed, strong and active coalitions with many entities will be necessary.

5.1 Analysis

There are many states attempting to support deployment of small modular reactors. Governor Mark Gordon in Wyoming is advocating for TerraPower's Natrium reactor to be built in Kemmerer; through the leadership of Governor Greg Abbott, Texas is investigating the potential of small nuclear reactors by working with Dow and X-energy; and Governor Glenn Youngkin and Dominion Energy recently announced a request for proposal for developing and constructing an advanced small modular reactor in Virginia. South Carolina is considering a reboot/completion approach for the VC Summer nuclear units that stopped construction in 2017.

The private sector is also weighing in in ways unheard of just a year ago. Microsoft's recently announced power purchase agreement with Constellation underpins the effort to restart the Three Mile Island Nuclear Station Unit 1 in Pennsylvania. Amazon Web Services (AWS) recently purchased the Cumulus data center co-located with the Susquehanna nuclear station, also in Pennsylvania. These companies are offering significant rate incentives per kilowatt-hour. Kairos Power and Google have signed an agreement to facilitate the development of a 500-MW fleet of molten salt nuclear reactors by 2035 to power Google's data centers. The first reactor is expected to be operational by 2030. Amazon has also led a $500M investment in X-energy to fund the completion of their reactor design and licensing as well as the first phase of its TRISO-X fuel fabrication facility in Oak Ridge.

Federal and state governments are making unprecedented moves to support nuclear as well. The federal government will provide a $1.5 billion loan to restart the Palisades nuclear power plant in southwestern Michigan owned by Holtec International. Holtec acquired the Palisades plant in 2022 with plans to dismantle it but has switched its strategy with a goal of restarting it by late 2025. In California, regulators said the Diablo Canyon nuclear plant, owned by Pacific Gas and Electric, could operate through 2030 instead of 2025.

Utilities, energy end users, reactor manufacturers, as well as state and federal entities, can be essential partners as Tennessee seeks to advance new nuclear. The pressure to capitalize on installed but idle nuclear plants (Palisades, VC Summer, and Three Mile Island) is evidence of the urgency playing through this landscape.

5.2 Conclusions and Recommendations

Conclusion 5-A:

No single entity can bring new nuclear to life. Partnerships and coalitions will be essential to successful deployment of new nuclear at scale.

Recommendation 5-A-1:

The Governor should continue to leverage and even enhance his position as a national leader and advocate for coalition building with federal officials and governors representing the Tennessee Valley, the Southeast, and beyond. New nuclear is and should be a national security interest, and energy independence will be a key to maintaining the nation's role as a global leader.

The seven-state region served by TVA as well as other states in the Southeast can bring significant support to deployment of new nuclear. Many of these states have already indicated they want to advance nuclear power in their own states. Collectively working to solve the FOAK cost challenge will benefit the entire Southeast.

Governor Lee facilitates energy discussion with SC Governor Henry McMaster, LA Governor Jeff Landry and NE Governor Jim Pillen at the Southern States Energy Board meeting in Chattanooga on Sept. 22, 2024.

Recommendation 5-A-2:

To advocate and raise awareness for the need and promise around new nuclear, establish a strong and unified communications effort and platform, perhaps coordinated through the Joint Office of Nuclear Advancement, to insure consistent and uniform objectives and messaging that communicates Tennessee's long-term desire and vision for abundant power, energy independence, and economic growth, as well as the Governor's leadership role in fostering regional and national energy collaboration.

Recommendation 5-A-3:

Through the Joint Office of Nuclear Advancement (Recommendation 4-A-1), explore partnerships with non-profit organizations to address opportunities to strengthen technical expertise, advocacy, regulatory support, and independent assessments.

Tennessee is partnering with numerous non-profit organizations within the nuclear sector that have proven valuable in promoting the state's nuclear projects and initiatives. These partnerships have expanded the visibility of Tennessee's efforts, helping to increase recognition and engagement from a broader audience. By leveraging these relationships, the State has enhanced public awareness and support for its nuclear energy advancements.

Recommendation 5-A-4:

The Council has proven to be a useful entity for collaboration, convening, idea exploration, and support of State efforts to identify and act on opportunities to grow new nuclear generally, and to support the potential, future deployment of an SMR at the Clinch River Nuclear site specifically. Continuity of those functions should be considered, perhaps as a 3-year pilot task force organized around identified objectives, goals, deliverables, and members, all to be determined following evaluation of the report and recommendations.

TNEAC Vice Chair Jeff Smith (standing) outlines elements of the Council's priorities for nuclear energy generation and supporting supply chain expansion.

Summary

Tennessee is well-positioned to be a leader in new nuclear. Building upon a strong foundation of nuclear experience and working with TVA, Tennessee can assure a bright future for the citizens of the State powered by clean, reliable, nuclear energy. However, the prospect of increasing Tennessee's use of this carbon-free energy source is not without challenge. Addressing FOAK deployment costs is the biggest challenge Tennessee and the entire nuclear industry face.

With focus, some investment, and a sense of urgency, Tennessee can advance new nuclear to where it is affordable and available to Tennessee and neighboring states served by TVA.

Some financial investment to help with FOAK costs, improved incentives for attracting the nuclear supply chain, better coordination on workforce development, some targeted improvements in regulatory functions controlled by the State, and broad coalitions aligned with a shared goal, can bring new nuclear to reality in a way that will serve Tennessee for generations to come.

Tennessee is not starting from scratch -- the collection of nuclear assets already present, along with others that have announced they are coming, form a springboard unmatched in the nation. Tennessee is open for business in nuclear.

Ensuring affordable energy independence and security means putting nuclear energy on the grid. This will take focus, partnership, collaboration, investment, efficiency, and urgency.

- Anderson County Mayor Terry Frank, TNEAC Member

Appendices:

Appendix A: Tennessee Nuclear Energy Advisory Council Members

Tracy S. Boatner
President & CEO
East Tennessee Economic Council (ETEC)

Tracy is the President & CEO of the East Tennessee Economic Council, a nonprofit membership organization dedicated to leveraging East Tennessee's federal assets for economic growth. Tennessee Valley Authority, Oak Ridge National Lab, and Y-12 National Security Complex are a few of the region's unique federal assets. Working with these partners, ETEC's Nuclear Working Group organizes an annual Nuclear Opportunities Workshop (NOW). NOW gathers hundreds of attendees from across the nation each year to feature Tennessee's expertise in all things nuclear and to drive interest in the state's robust nuclear industry.

Tracy serves as a Fellow of the University of Tennessee's Center for Energy, Transportation, and Environmental Policy at The Baker School of Public Policy and Public Affairs. Her community leadership roles include Board Chair of United Way of Anderson County; Board Member of YWCA of Greater Knoxville; Alumni of Leadership Knoxville Class of 2012; Past President of Rotary Club of Oak Ridge; Board Member of Center for Leadership & Community Development; and Alumni of Leadership Oak Ridge Class of 2016.

Representative Clark Boyd
Tennessee House of Representatives
District 46

Clark is a member of the Tennessee House of Representatives, representing District 46 since January 2018. Clark grew up in Virginia and later attended East Tennessee State University, where he earned a Bachelor of Science degree in Human Development and Learning with a Minor in Military Science. His educational background laid a strong foundation for his future endeavors in both business and politics. Clark served as a Captain in the US Army Reserve, with 11 years of service in the US Army and Army National Guard. His military experience has been a cornerstone of his leadership style and commitment to public service.

Clark was appointed to the Tennessee House of Representatives in 2018 to fill the vacancy left by then Rep. Mark Pody once Pody was appointed to the Senate. Clark has since been re-elected and continues to serve his constituents with dedication. During his tenure, Clark has been actively involved in several key committees, including the Commerce Committee, Finance, Ways, and Means Committee, and Health Committee. He currently serves as Chairman of the Business and Utilities Subcommittee.

He has sponsored numerous bills and has been a strong advocate for reshaping energy policy in Tennessee. Notably, Clark sponsored H.B. 0946 enacted July 2023 that established nuclear power is a permissible source of clean energy used by a public utility. The legislation also established that nuclear power is a permissible source of renewable energy used by a public utility.

Clark is actively involved in his community. He has served as the President of the Rotary Club of Lebanon, the Wilson County Habitat for Humanity, and is a board member of Living Sent Ministries. He is also a deacon and Sunday School teacher at Immanuel Baptist Church in Lebanon. Clark and wife, Jada, have two children, Wilson and Blair Ellen. The family resides in Lebanon where they are active members of their church and community.

Adam DeMella
Principal
ADG Strategies, LLC

Adam DeMella is the founder of AMM Strategies, a strategy, government relations and communications consulting firm specializing in nuclear energy and national security. He serves as a Senior Advisor to the leadership of his client companies, responsible for developing strategic partnerships to drive growth and support domestic and international national security and nuclear initiatives.

Adam has over 30 years of experience in nuclear technology and policy, national security, political and legislative strategy, and communications. He is an expert in the government funding process, with executive-level experience in both Congress and the Executive Branch.

Prior to starting his own firm, he was a Senior Vice President at GE-Hitachi, supporting effort to deploy new small modular reactors. Prior to joining GE, Adam worked for Oak Ridge National Laboratory as the Director of Federal Affairs. He previously served as Professional Staff Member for the Senate Committee on Appropriations, overseeing the portfolio that included all nuclear and national security funding within the Department of Energy. Before that, he spent 20 years at Naval Reactors, serving in several roles that included engineering and program management, budgeting, acquisition, and federal affairs. He lives near Annapolis, Maryland with his wife and two children.

Terry Frank
County Mayor
Anderson County

Terry Frank is the Mayor of Anderson County, first elected in 2012. She currently serves on the Tennessee Advisory Commission on Intergovernmental Relations (TACIR), the board of East Tennessee Economic Development Agency (ETEDA), Association of Tennessee Valley Governments (ATVG), and is Chair of District 2 Homeland Security Council, as well as President of the Tennessee Association of County Mayors. Additionally, she serves on the Tennessee Commission on Aging and Disability, is Chair of the

Knoxville Regional Transportation Planning Organization, and serves on various other boards and committees.

A native Tennessean, Terry attended Sewanee: the University of the South, and Middle Tennessee State University where she earned a Bachelor of Arts in Political Science. She and her husband Lee owned and operated a small business in Oak Ridge for over 20 years. Together they have three adult sons, two daughters-in-law, and three grandchildren.

Michelle Amante-Harstine
Founder and CEO
Congressional Energy Engagement LLC (CEE)

Michelle leads Congressional Energy Engagement as a driving force for government engagement programs, promoting clean energy solutions and advancing the nation's leadership in energy. The impact of CEE spans bipartisan Members of Congress, the Administration, C-level industry leaders, and key stakeholders. Michelle and CEE are recognized for developing the U.S. Congressional Energy Leaders Forum, now the Nuclear Policy Leadership Dinner Discussion series under the American Nuclear Society. The firm also works with international entities to foster global partnerships and solutions. A prime example is Michelle's creation of the *World Nuclear Forum – Excellence Through Global Collaboration – Nation by Nation*, an annual event that brings international experts and innovators to the U.S.

While CEE focuses primarily on nuclear fission and fusion technologies, it also collaborates with other clean energy developers, ensuring an inclusive approach to energy innovation. Michelle and CEE are connected to global energy think tanks, universities, and other stakeholders to promote transformative innovation in clean energy. Their efforts support the advancement of U.S. energy leadership, national security, and energy prosperity, all while aligning with the mission of her clients.

Michelle has more than 25 years of experience spanning both the public and private sectors. Her entrepreneurial journey began during her tenure at the U.S. Department of Energy's Office of Nuclear Energy, where she served as Senior Advisor for Stakeholder Engagement. Currently, as a Senior Fellow for the United States Nuclear Industry Council and a member and the Tennessee Nuclear Energy Advisory Council, Michelle plays a key role in shaping nuclear energy policy at both national and state levels. Though her primary work is based in Washington, D.C., Michelle stays connected to her home in Tennessee. She is involved in initiatives like "Navigating Nuclear: Energizing our World" and immersive programs for Oak Ridge National Laboratory and university students. Whether in the nation's capital or back in Tennessee, CEE and Michelle consistently transcend traditional boundaries, fostering cross-sector collaboration and helping clients achieve their strategic goals in clean energy transformation.

H.M. "Hash" Hashemian, Ph.D.
President and CEO
AMS

Hash is President and Chief Executive Officer of AMS; a nuclear engineering firm operating since 1977 in the United States, Europe, and Asia. He has 47 years of experience in development and delivery of industry-leading instrumentation and control system testing and analysis equipment, training, and services.

Hash holds three doctorate degrees in engineering including a Ph.D. in nuclear engineering, a Doctor of Engineering degree in electrical engineering, and a Ph.D. in computer engineering. He has written three technical books published in English, Chinese, Japanese, Korean, and Russian. He is also the author or co-author of 22 U.S. patents and nearly 400 journal articles, conference papers, and technical reports.

Dr. Hashemian is a Fellow of three professional societies including the American Nuclear Society, Institute of Electrical and Electronics Engineers, and International Society of Automation. He is also an adjunct professor of nuclear engineering at the University of Tennessee, and an adjunct professor of practice at the Woodruff School of Mechanical Engineering at Georgia Institute of Technology. In 2024, he was elected by the American Nuclear Society as its Vice President (2024-2025) and then President (2025-2026). For Dr. Hashemian's executive profile and full resume, please consult www.ams-corp.com/management

J. Wesley Hines, Ph.D.
Nuclear Engineering, Distinguished Postelle Professor, and Chancellor's Professor
The University of Tennessee, Knoxville

Wes is a Professor in the Nuclear Engineering Department at the University of Tennessee, is the Distinguished Postelle Professor and a UT Chancellor's Professor. He has served 13 years as Nuclear Engineering Department Head, as Interim Associate Dean for Research in the College of Engineering and as Interim Vice Chancellor for Research for the Campus. Wes received a BS degree in Electrical Engineering from Ohio University in 1985, and then served as a nuclear qualified submarine officer in the US Navy. He later received both an MBA and an MS in Nuclear Engineering from The Ohio State University in 1992, and a Ph.D. in Nuclear Engineering from The Ohio State University in 1994. He has served the University of Tennessee for 30 years. Under Wes' leadership, his department has grown to the largest Nuclear Engineering PhD program in the US and has been ranked as high as 4th ranked by US News and World Reports.

Wes has authored over 350 technical papers and is invited to speak around the world on topics ranging from his research activities in artificial intelligence, nuclear engineering education, reliability and maintainability education, and national nuclear strategy. His notable academic and scholarly accomplishments have been recognized by the American Society for Engineering Education (ASEE)

Nuclear Engineering Division, through their Glenn Murphy Distinguished Nuclear Engineering Educator Award in 2014, he was selected as an American Nuclear Society Fellow in 2015, and was the recipient of the American Nuclear Society, Arthur Holly Compton Award in Education in 2019, and the Robert Long Training Excellence award in 2020. He is the current University of Tennessee Macebearer, the highest faculty honor which recognizes a distinguished career and commitment of service to students, scholarship, and society.

Chris Jones
President/CEO
Middle Tennessee Electric (MTE)

Chris is Middle Tennessee Electric's President and just the fifth CEO in the cooperative's 88-year history. A 25-year veteran of MTE, he is a graduate of the University of Tennessee, Knoxville, where he earned his degree in communications. During his tenure as CEO, Jones has navigated the organization through several severe weather events, significant upgrades in technology, improvements in member satisfaction to best-in-class levels, and a merger with the Murfreesboro Electric Department. Chris helped spearhead efforts to persuade the State of Tennessee to allow electric cooperatives to provide broadband services to rural areas. In 2018, MTE partnered with United Communications to expand broadband in underserved Middle Tennessee Counties.

Chris is active in Middle Tennessee, serving MTE members and the community through several avenues. He is past chair of the Rutherford County Chamber of Commerce and current chair of Destination Rutherford, and he is past chair and current board member of Williamson Inc. He is a board member of United Communications, the Tennessee Electric Cooperative Association, the Tennessee Chamber of Commerce, and the Middle Tennessee Industrial Development Association.

In 2022, Chris received the National Rural Electric Cooperative Association's J.C. Brown CEO Communication Leadership Award, which recognizes an electric cooperative or public power district CEO/general manager committed to advancing communication. Chris has also been awarded the Pinnacle Award from Leadership Rutherford, the Business Person of the Year Award from the Rutherford County Chamber of Commerce, and the Rutherford County Impact Award from the Nashville Business Journal. In 2017, he was named a Distinguished Alumnus of Motlow State Community College. Chris lives in Murfreesboro with his wife, Bonita, who is a retired teacher. They have two grown daughters, Cayln and Chrisln.

Steve Jones
President
Steve Jones & Associates

Steve Jones is an East Tennessee native who grew up in the rural area around the large Federal assets such as TVA, Y-12, and ORNL. Steve has led a distinguished career as a public servant, both within the United States Air Force and within East Tennessee as a business & economic development leader and City Manager of his hometown of Clinton, Tennessee.

Steve serves on the UT/Battelle Development Corporation board of directors, the Tennessee Valley Corridor board of directors, and is an executive board member of the East Tennessee Economic Council. Steve is former Commissioner of the Tennessee Fish and Wildlife Commission and was appointed by Governor Lee in 2023 to serve on the Tennessee Nuclear Energy Advisory Council.

Maria Korsnick
President and Chief Executive Officer
Nuclear Energy Institute (NEI)

Maria Korsnick is president and chief executive officer of the Nuclear Energy Institute, the nuclear industry's policy organization in Washington, D.C., a role she has held since January 1, 2017. Drawing on her engineering background, hands-on experience in reactor operations and a deep knowledge of energy policy and regulatory issues, Maria aims to increase understanding of nuclear energy's economic and environmental benefits among policymakers and the public.

The Export-Import Bank of the United States has appointed her to its Advisory Committee and its Council on China Competition; and the U.S. Department of Energy has appointed her to its Nuclear Energy Advisory Committee. She also serves as a member of the board of directors of the U.S. Energy Association; National Energy Foundation; Center for Energy Workforce Development; and the Foundation for Nuclear Studies. She also serves as a trustee of the Nuclear Power Labor Management Cooperation Committee Trust and vice chair of the University of Maryland Department of Mechanical Engineering Visiting Committee.

Before joining NEI, Maria held senior leadership positions in the private sector, including senior vice president of Northeast Operations for Exelon, chief nuclear officer (CNO) and acting chief executive officer at Constellation Energy Nuclear Group. Maria holds a bachelor's degree in nuclear engineering from the University of Maryland and has held a Senior Reactor Operator license. She lives in Maryland with her husband, and they are the parents of two adult children.

Don Moul
Executive Vice President and Chief Operating Officer
Tennessee Valley Authority

Don serves as TVA's Executive Vice President and Chief Operating Officer. With more than 37 years of experience in power generation and operations, he possesses a strong track record of enhancing operational performance and teamwork through a disciplined and collaborative leadership approach.

In his key leadership role at TVA, Don has responsibility for TVA's power generation, transmission, and power supply functions. With one of the nation's most resilient, diverse generation portfolios, he leads TVA's industry-leading efforts to provide increasingly cleaner energy. Don also leads a number of other mission-critical areas of TVA's business, including Integrated River System Management; Natural Resources; Environment and Sustainability; Supply Chain; Major Projects; TVA Police and Emergency Management; Enterprise Improvement; and the Clinch River Nuclear Project, which is exploring the viability of deploying small modular reactor technology. Don earned a Bachelor of Science in nuclear engineering from The Pennsylvania State University and an MBA from the University of Notre Dame. He also has been a senior reactor operator at multiple nuclear stations.

TVA and its employees, including Don Moul, an officer of TVA, participated in the Council to provide information on issues related to the state of the nuclear industry, including factual information about TVA's nuclear program and the Clinch River Project, as well as insights to the Council based on Mr. Moul's professional experience in the nuclear industry. TVA and its employees are bound by federal ethics laws and policies concerning endorsements and lobbying, and TVA's and its employees' participation in the report should not be considered to be an endorsement of, or lobbying in favor of, any particular recommendations. TVA and Mr. Moul have recused themselves from the recommendations contained in the Council's Report.

Padma Raghavan, Ph.D.
Vice Provost for Research and Innovation, Distinguished Professor of Computer Science
Vanderbilt University

Padma is the Vice Provost for Research and Innovation and Chief Research Officer, Senior Advisor to the Chancellor, and Distinguished Professor of Computer Science at Vanderbilt University. As Vice Provost for Research and Innovation, Padma oversees the advancement of the university's research and innovation portfolio, including development of strategic partnerships. These partnerships include the Ancora Innovation, with Deerfield Management, to accelerate the development and delivery of life-changing therapeutics from bench to patient, and Army Pathfinder, a program to rapidly advance mission-critical science and technology.

In her faculty role, Padma specializes in supercomputing. She has authored over one hundred peer-reviewed publications and supervised nearly fifty M.S and Ph.D. theses. Padma has received several recognitions, including the National Science Foundation's CAREER award, elevation to Fellow of the Institute of Electrical and Electronics Engineers and Fellow of the American Association for the Advancement of Science. She is also active in the profession, currently serving on the advisory committees Office of International Science and Engineering at the National Science Foundation, and on the Board of Governors of UT-Battelle, which operates the Department of Energy's Oak Ridge National Laboratory. In 2022, Padma was appointed to a two-year term on the President's Committee on the National Medal of Science.

Ken Rueter
United Cleanup Oak Ridge (UCOR)
President and Chief Executive Officer

Ken is President and Chief Executive Officer of United Cleanup Oak Ridge (UCOR), directing the $8.3 billion Oak Ridge Reservation Cleanup Contract for the Department of Energy's Oak Ridge Office of Environmental Management. He leads a professional and skilled labor workforce of 2,500, working to reduce risks and environmental liabilities, make restored land available for reuse, and facilitate economic opportunities for the region.

Prior to the current contract, Ken led the successful cleanup of the East Tennessee Technology Park, the largest environmental cleanup project in DOE's history and the world's first uranium enrichment site cleanup. In addition to serving on Governor Bill Lee's Tennessee Nuclear Energy Advisory Council, Rueter is chair of the Oak Ridge Associated Universities (ORAU) Board of Directors.

David W. Salyers, P.E., P.G.
Commissioner
Tennessee Department of Environment & Conservation

David was appointed Commissioner in January 2019 by Governor Bill Lee after serving as Executive Director of the West Tennessee River Basin Authority for 20 years. He represents the Administration and TDEC on priority interagency efforts to improve natural resource management, rural economic development, and outdoor recreation opportunities in Tennessee. In his role, he has also led high-level executive partnerships with the U.S. Department of Energy (DOE) for the Oak Ridge Reservation and successfully worked through a variety of issues with the U.S. Army Corps of Engineers. Over the past two years, David has been instrumental working with the Governor's Office to develop Tennessee's plan for water and wastewater investments through the American Rescue Plan via the *TN Water Infrastructure Investment Program (TWIIP)* and leading development of Governor Lee's Tennessee Conservation Strategy. David has led deployment of historic capital investment in the Tennessee State Park system, including the establishment of eight new state parks.

Recently, David has been focused on implementation of record investments in State Superfund site cleanups and accelerated reclamation through new programs for brownfield site cleanup and redevelopment, including the Brownfield Redevelopment Area Grants or BRAG program. David is honored to serve as Chairperson for the Tennessee Nuclear Energy Advisory Council established by Governor Lee's Executive Order 101 – an opportunity to leverage TN's competitive advantages to become a leader in nuclear energy and supply chain for the region, nation and world. David holds an undergraduate degree from Murray State and earned both bachelor's and master's degrees from Missouri University of Science and Technology.

Patrick C. Sheehan
Director
Tennessee Emergency Management Agency

Patrick was appointed as the Director of the Tennessee Emergency Management Agency in 2016. Patrick advises Governor Bill Lee on all aspects of emergency management policy and serves as Tennessee's principal liaison to the Federal Emergency Management Agency. He previously served in several roles at the Ohio Emergency Management Agency from 2003 to 2016. Prior to serving in emergency management, he was an enlisted member of the United States Army Reserve as a Nuclear, Biological, and Chemical Specialist and completed Army Airborne School. He also worked in the private sector, helping to run his family's businesses in the Atlanta area. Director Sheehan holds a bachelor's degree in business administration from Kennesaw State University and is currently pursuing his master's degree from Lipscomb University. He is a graduate of the Naval Postgraduate School Center for Homeland Defense and Security Executive Leaders and the Radiological Emergency Preparedness Executives programs. He was also a fellow in the Federal Emergency Management Agency's inaugural Vanguard Crisis Leadership Program in 2022 and is a part of the Harvard Global Crisis and Resilience Forum.

Patrick chairs Tennessee's State Emergency Response Council and is a member of the Nashville Joint Terrorism Task Force, Tennessee's Cyber Security Council, the U.S. Department of Homeland Security's First Responder Resource Group, the Public Safety Advisory Council for the FirstNet Authority, the Tennessee Nuclear Energy Advisory Council and serves in other emergency management, homeland security, and public safety and service organizations. Patrick is Chairman of the Central U.S. Earthquake Consortium Board of Directors and is the current President of the National Emergency Management Association. An Eagle Scout, Patrick and his family continue to be engaged in scouting in Middle Tennessee.

Jeff W. Smith
Vice President for National Labs, Office of the President
University of Tennessee

Jeff serves as vice president for national labs, the University of Tennessee System's primary liaison to the Oak Ridge National Laboratory (ORNL) leadership team, the U.S. Department of Energy and Battelle Memorial Institute on matters that relate to the UT-Battelle management and operations contract for ORNL. Prior to joining UT's Office of the President, Jeff worked nearly four decades with Battelle, including serving as deputy for operations at ORNL from 2000 to 2021. During his 21 years as deputy for operations, Jeff led a $750 million modernization of ORNL that transformed the dated facilities of the Manhattan Project-era site into one of the world's most modern laboratories. In 2023, Jeff was asked by the UT-Battelle board of directors to return as interim lab director where he served until October 2023. As interim lab director of ORNL, Jeff led more than 6,500 staff members with an organizational budget of $2.7 billion to deliver on critical national missions for the U.S. Department of Energy by leveraging Oak Ridge National Laboratory's (ORNL) world-leading facilities.

Jeff currently serves as a board member of the UT-Battelle Development Corporation, where he served as president from 2002 to 2023. He also serves as Vice Chair of the Tennessee Nuclear Energy Advisory Council for the State of Tennessee. Previously, he served on the Tennessee Valley Authority board of directors from 2017 to 2022, the Knoxville Metropolitan Airport Authority board of commissioners from 2005 to 2023 and the Cherokee Farm Development Corporation/Cherokee Farm Properties, Inc. board of directors from 2013 to 2022. He and his wife, Debbie, of 41 years have three daughters and three grandchildren. Jeff is an instrument rated pilot; has built two airplanes, one being a Carbon Cub that he now flies along with a Cirrus SR22.

Jennifer Stone, P.E.
Vice President
Consor Engineers

Jennifer Stone is a professional Civil Engineer that has provided management and technical expertise to infrastructure and nuclear projects for more than 25 years. She specializes managing in large construction projects, as well as, providing effective public communication to relay complex project information in ways that are easily understood. Jennifer is active in several industry organizations that have enabled her to build an extensive professional network which she uses to work proactively across industries. Jennifer is passionate about mentoring the next generation of workforce and advocating for developments that improve the quality of life in her community. Outside of her professional work Jennifer enjoys painting, hiking and gardening.

Braden Stover
Chief Policy Officer
Tennessee Department of Economic and Community

As Chief Policy Officer at the Tennessee Department of Economic and Community Development (TNECD), Braden helps the department successfully navigate policies, rules, laws, and relationships with the Governor's Office and Legislature. In 2023, Braden was appointed by Governor Lee to the newly formed Tennessee Nuclear Energy Advisory Council and has been on point to develop programmatic policies for the new Nuclear Energy Supply Chain Investment Fund established by Governor Lee in 2023 and funded by the General Assembly for two consecutive years. The "Nuclear Fund" has successfully recruited more than 600 new nuclear jobs to the state along with billions in committed capital investment and provided significant support to key workforce development initiatives across Tennessee higher education.

Additionally, Braden has supported the Transportation Network Growth Opportunity (TNGO) initiative at TNECD, which has the goal of attracting more research and development investment to Tennessee. Before joining TNECD, Braden worked for U.S. Senator Bill Hagerty, U.S. Representative John Rose (TN-6), and State Senate Majority Leader Jack Johnson (TN-23). Braden is a graduate of Belmont University and currently resides in Mt. Juliet with his growing family.

Lang Wiseman
Counsel
First Horizon Corporation

Lang is a native Tennessean who attended the University of Tennessee on a basketball scholarship before going on to Harvard Law School, graduating from both summa cum lade. He later grew a private practice as a high stakes litigator before being called to public service. From 2019 to 2021, Lang served as Deputy Governor and Chief Counsel to Tennessee Governor Bill Lee, acting as a liaison between the governor's office, the legislature, and the various departments and agencies in state government. As Chief Counsel and the state's Chief Ethics Officer, Mr. Wiseman coordinated the legal and regulatory affairs of the executive branch and advised Governor Lee on legal, political, and legislative matters. He assisted in development, drafting, and implementation of legislation and worked closely with the judiciary and the attorney general and reporter. He was also responsible for assisting Governor Lee with judicial appointments, requests for executive clemency, and implementation of economic development programs at the state level.

Prior to his appointment, Lang was a founding partner at the Memphis law firm Wiseman Bray PLLC. He is a member of the University of Tennessee Board of Trustees and chair of the Governor's Council for Judicial Appointments. Lang is also a member of the University of Tennessee Research Foundation Board of Directors, TennSMART Board of Directors, Tennessee Economic Development Council and Tennessee Artificial Intelligence Advisory Council.

While consistently listed among “Best Lawyers in America” and a “Super Lawyer” for the state and region, Lang is better known for his self-deprecating sense of humor, strategic insights, common sense savvy, and being a SEC Basketball Legend.

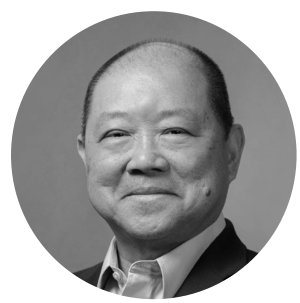
Senator Ken Yager
Tennessee State Senate
District 12

Sen. Yager is honored to represent nine of the finest counties in the Tennessee Senate: Campbell, Clay, Fentress, Macon, Morgan, Overton, Pickett, Roane, and Scott. In Nashville, it is his priority to represent the values and interests of his district. For 47 years, Ken has had the privilege to serve the public. First, as a teacher in the then Harriman City Schools, later as the Roane County Attorney, and then as Roane County Executive for six terms. Through his decades of experience in local government, he gained valuable knowledge—learning to work together to accomplish a goal, being a good listener, and respecting those he may disagree with. This understanding has helped Ken to be an effective state senator.

Ken was first elected to the Tennessee Senate in 2006. In 2018, his Republican colleagues in the Senate elected Ken to Leadership as Chairman of the Senate Republican Caucus. In this position, he works to advance conservative values in the Senate, and he is grateful that his colleagues have trusted him with this important role.

During his time in the Senate, Ken has served on several key committees, including Commerce and Labor, Finance, Ways and Means, and the Fiscal Review Committee. He is also the Chair of the Tennessee Advisory Commission on Intergovernmental Relations (TACIR) and a member of the State and Local Government Committee. Additionally, he has had the honor of chairing the Senate State and Local Government Committee and the Joint Fiscal Review Committee. In 2023, Governor Lee appointed Ken to the TN Nuclear Energy Advisory Council.

Loong Yong, Ph.D.
President
SpectraTech



Loong Yong has a B.S., M.S., and Ph.D. in Nuclear Engineering. He has more than 30 years of experience in radiological engineering, nuclear safety, environmental remediation, special nuclear materials disposition, and nuclear and hazardous waste management. Loong’s extensive experience includes work at U.S. Department of Energy facilities and commercial nuclear power plants. In 1995, Loong founded Spectra Tech, Inc., a 300-person nuclear, engineering, and environmental services company based in Oak Ridge, TN. Loong is a member of the University of Tennessee Nuclear Engineering Hall of Fame and a current board member of Waste Management Symposia, East Tennessee Economic Council, Oak Ridge Civic Music, and the Guitar Foundation of America. In 2023, he was appointed by Governor Bill Lee to the Tennessee Nuclear Energy Advisory Board.

Appendix B: Tennessee Nuclear Business and Regulatory Survey – Insights from the Nuclear Community

Nuclear Business and Regulatory Survey

Insights from the Nuclear Community

Tennessee Nuclear Energy Advisory Council | Survey Results | August 2024

Nuclear Business and Regulatory Survey

Executive Summary

This report provides a comprehensive analysis of Tennessee's nuclear industry, drawing from survey responses to identify key trends, challenges, and opportunities. The Tennessee Nuclear Energy Advisory Council's subgroup, the Business and Regulatory team, created the Business and Regulatory survey to identify key trends, challenges, and opportunities. Its findings offer valuable insights into the current state of the industry and highlight areas for future focus. Below are the most significant insights drawn from the survey, categorized by key areas of interest.

Key Findings

- **Respondents:** The survey showed that 66.7% of respondents were private companies, with 54% being small businesses with fewer than 100 employees. This highlights the private sector's dominant role and the importance of small enterprises in Tennessee's nuclear industry.

- **Important Sub-Sectors**: While Nuclear Power Generation remains central, there is a growing anticipation of an increase in fusion technology (50% criticality increase in 5-15 years), indicating the need for strategic investments in this emerging area.

- **Critical Resources:** Skilled labor emerged as the most critical resource, with respondents emphasizing the importance of workforce development and targeted incentives to attract and retain talent, alongside significant investments in computing and AI technologies.

- **Siting Considerations:** Proximity to other nuclear organizations is a key factor in site selection, with 72% of respondents expanding in Tennessee considering it important, underscoring the value of industry clustering for collaboration and efficiency.

- **Education and Workforce**: There is a perceived need for improvement in nuclear education programs, particularly among those actively involved in educational pipelines, highlighting the necessity for better alignment with industry needs.

- **Regulatory Environment**: 75.9% of respondents say Tennessee's regulations are conducive to nuclear technology growth, while most still find certain processes, like the national NQA-1 Certification standard, to be "Costly or Burdensome" (70%), presenting opportunities to streamline. Respondents also highlighted that providing consistent regulatory support is a critical need.

- **Incentives**: The Tennessee Nuclear Fund was known by 88.3% of industry respondents who saw it as a positive step while also calling for additional financial incentives like tax abatements and grants to attract businesses.

The insights gathered from this survey provide a clear picture of the current strengths and challenges within Tennessee's nuclear industry. The findings coincided with a recent poll at the East Tennessee Economic Council's Nuclear Opportunities Workshop. They both emphasize the critical need for workforce development, the importance of strategic siting, and the necessity of enhanced educational programs and incentives. Addressing these areas will be crucial for Tennessee to maintain its leadership in the nuclear sector and to capitalize on future growth opportunities.

Nuclear Business and Regulatory Survey

Table of Context

Introduction

The Tennessee Nuclear Energy Advisory Council was established by Governor Bill Lee under Executive Order 101 with the mission of positioning Tennessee as a national leader in nuclear energy innovation and advancement. Comprising twenty members with extensive experience across various facets of the nuclear sector, the Council drives investment and creates a thriving nuclear energy ecosystem that will fuel Tennessee's economic growth, energy independence, and environmental stewardship. Governor Lee's vision is clear: "Tennessee can lead America's energy independence and deliver continued economic growth with safe, reliable, and clean nuclear energy for the future. I am confident that these appointees will use their unique industry expertise to ensure that Tennessee is the top state for nuclear energy companies to invest and succeed, creating quality jobs and greater opportunity for Tennesseans."

A dedicated subgroup of the Council, the Business and Regulatory team, played a crucial role in this effort by developing the Business and Regulatory Survey. Composed of three council members, this team focused on analyzing Tennessee's regulatory framework, evaluating business opportunities, and assessing state incentives. Their objective was to make Tennessee the most attractive location for priority nuclear sector companies, both in the near and long term. The survey they developed, consisting of 38 detailed questions, was designed to gather direct input from industry stakeholders on a range of critical topics, including demographics, nuclear subsectors, critical resources, siting considerations, education and workforce, regulatory environment, and incentives.

The survey, which was open from June 20th to August 15th, 2024, was distributed widely with the assistance of the East Tennessee Economic Council (ETEC) and the Tennessee Advanced Energy Business Council (TAEBC). These organizations were instrumental in ensuring that the survey reached diverse respondents, including small businesses, large enterprises, and other stakeholders throughout Tennessee's nuclear sector. Concurrently, a poll conducted by the ETEC at their annual Nuclear Opportunities Workshop in July echoed similar sentiments, underscoring the importance of a supportive regulatory environment and targeted incentives for nuclear businesses. The alignment of findings from both the survey and the poll reinforces the need for strategic actions to address regulatory and business challenges in Tennessee.

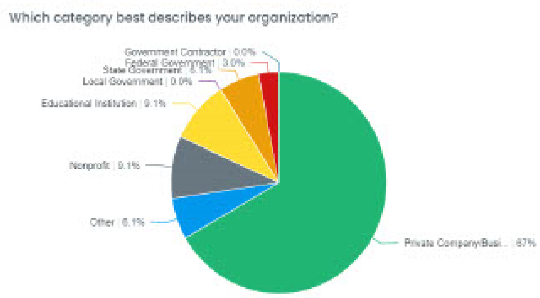
The findings from this survey are crucial to the Council's final report, which will be submitted to Governor Lee by October 31st, 2024. This report will outline a strategic path forward for Tennessee, ensuring energy independence and environmental sustainability.

Respondents: Organizational Insights

This survey had 36 respondents. Understanding their demographics and characteristics provides valuable context for interpreting their responses.

Organizational Categories and Sectors

The survey asked respondents to categorize the organization they represent. The responses revealed a wide range of organizational types, including private companies, government agencies, educational institutions, and nonprofits. Notably, **66.7%** of the respondents were private companies, reflecting the significant presence of the private sector in Tennessee's nuclear industry. In contrast, **6%** of respondents identified as government agencies.



Respondent Types.

The survey also asked respondents about the sectors of the nuclear industry they work in, such as nuclear fuel processing, higher education, radiological health, nuclear security, and spent fuel. Though nuclear service and fission power were mentioned most, the respondents' diversity highlights the multifaceted nature of the nuclear industry in Tennessee, with many organizations working across multiple sub-sectors to support the state's energy and technological needs.

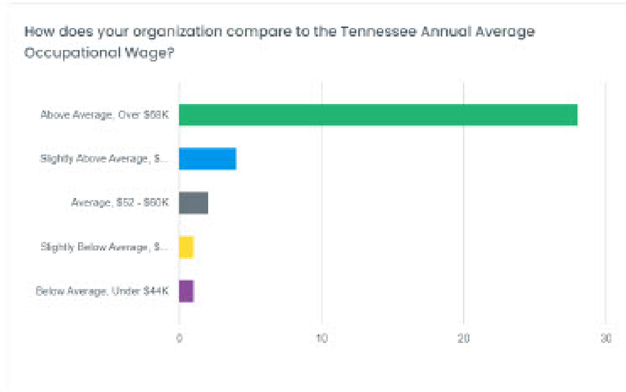
Physical Presence and Expansion Interest

A critical aspect of the survey was understanding the respondents' geographical footprint. The data showed that **64%** of the respondents have an established physical presence in Tennessee, demonstrating the state's strong role in the nuclear industry. Moreover, **55%** of the respondents expressed interest in expanding or relocating their operations to Tennessee. This interest underscores the potential for growth in the state's nuclear sector, driven by its favorable business environment, strategic location, and commitment to supporting the industry. The combination of an existing strong presence and significant interest in expansion suggests that Tennessee is well-positioned to attract further investment in the nuclear field.

Organizational Size and Wage Competitiveness

Understanding the size and wage competitiveness of the organizations provides additional insights into their operational capabilities and economic impact. The survey revealed a mix of both large and small organizations, with **54%** of respondents representing small businesses with fewer than 100 employees, making this the largest group.

Regarding wage competitiveness, an impressive **89%** of the respondents indicated that their wages are above the Tennessee Annual Average Occupational Wage, as per the January 2024 data from the Tennessee Department of Revenue[1]. This finding indicates the high skill levels required in the nuclear industry, where specialized knowledge and experience are often compensated with higher-than-average salaries.



Organizational Wage.

Experience in the Nuclear Industry

The survey also explored the longevity of the organizations within the nuclear industry. Responses indicated a wide range of experience, with several organizations having operated for **more than 26 years**. Notably, the majority of these long-established organizations were identified as private companies. This emphasizes the significant role that private businesses play in the nuclear industry, particularly among those with extensive experience.

The demographic profile of the respondents paints a comprehensive picture of Tennessee's nuclear industry. The majority of respondents are well-established private companies with a strong physical presence in the state. However, there is also significant interest from organizations looking to expand or relocate to Tennessee, highlighting the state's attractiveness as a hub for nuclear activities.

With a mix of large and small organizations, competitive wages, and a balance of long-standing experience and new entrants, Tennessee's nuclear industry is both robust and poised for future growth. The insights gained from these demographic questions provide a solid foundation for understanding the needs, challenges, and opportunities facing the nuclear sector in Tennessee.

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[1] Tennessee Annual Average Occupational Wage, https://www.tn.gov/revenue/taxes/franchise---excise-tax/exemptions/job-tax-credit/annual-average-occupational-wage.html

Critical Nuclear Industry Sub-Sectors

The Survey has provided key insights into the anticipated growth of critical sub-sectors within the nuclear industry. This analysis isolates the differences between near-term (current or short-term) and long-term (future or expansion) predictions of criticality, highlighting five sub-sectors expected to see significant growth in importance.

Among these, **Fusion Power Generation** emerged as the most promising area, with a 50% increase in predicted criticality from near-term to long-term. One respondent emphasized, *"These sectors are where the industry is heading and in growth mode."* This suggests that fusion energy is seen as a key future technology, particularly by private companies, which were the most likely to foresee its growing importance. The potential of fusion as a clean and abundant energy source drives interest and investment in this area.

Medical Isotopes also saw a substantial 25% increase in importance, particularly highlighted by educational institutions and energy advisors. Respondents noted Tennessee's high potential for growth, with one remarking, "Highest potential for growth in Tennessee." This subsector's critical role in medical diagnostics and treatment ensures its growing relevance as the demand for advanced healthcare solutions continues to rise.

The **Back End of the Nuclear Fuel Cycle**, essential for the management and disposal of nuclear waste, showed a 25% increase in predicted criticality. Nonprofit organizations were particularly focused on this area, with one respondent underscoring its importance by stating, *"These are essential to the growth of the nuclear industry."* This highlights the need for sustainable and safe waste management practices as the industry evolves.

Fission Power or Heat Generation remains a cornerstone of the nuclear industry, with a 11% increase in its predicted importance. Private companies, heavily invested in this area, see it as a reliable source of energy crucial to meeting global energy demands. One survey respondent articulated this sentiment by saying, *"Increasing sustainable, net-zero carbon emission electrical power generation is crucial to our customers and stakeholders."*

Lastly, the **Front End of the Nuclear Fuel Cycle**, encompassing uranium mining and fuel fabrication, is expected to see a 27% increase in criticality. This sub-sector was most frequently highlighted by educational institutions, with predictions likely driven by the sheer volume of business and future needs, as noted by one respondent: *"Based on business volume."* This underscores the need for continued research and development to ensure a steady supply chain for the nuclear industry.

Private companies were the primary drivers behind the predicted growth in **Fusion Power Generation** and **Fission Power or Heat Generation**, reflecting their strong commercial interest in these areas. In contrast, **Medical Isotopes** and the **Front End of the Nuclear Fuel Cycle** were largely highlighted by educational institutions, while nonprofits focused on the **Back End of the Nuclear Fuel Cycle**.

Given these findings, it is recommended that the government strategically focus on supporting these five critical sub-sectors. This could involve targeted investments in research and development, incentives for private sector involvement, and the creation of policies that support the sustainable growth of these areas. By concentrating efforts on these emerging and expanding sub-sectors, Tennessee can position itself as a leader in the future of nuclear energy, driving economic growth and technological innovation for the long term.

Critical Resources

In analyzing the responses related to the specialized equipment, resources, or components critical to the nuclear industry over the next 1-15 years, four key categories emerged as the most significant: **Labor or Workforce**, **Funding**, **Computing or Artificial Intelligence (AI)**, and **Radiological Source Material**. These categories represent the core areas where the industry anticipates substantial challenges and needs.

Labor or Workforce

> *We most need a "quality workforce to meet the new manufacturing challenges"*

The most frequently mentioned critical resource was the availability and retention of skilled labor. Survey respondents repeatedly emphasized the challenges in finding experienced staff, particularly those with expertise in power generation, transmission, and distribution. One respondent noted that "Finding experienced staff with power generation, transmission, and distribution" is a significant long-term concern, reflecting the broader issue of workforce availability in the nuclear sector. Another respondent highlighted, "Likely the access to capable personnel will remain an issue into the 5-15 year time span," underscoring the ongoing difficulty in securing "Skilled craft workers and staff" as a long-term challenge.

Funding

Funding emerged as another crucial resource, especially concerning the support needed for education and continuous skill development. In particular, an institute of higher education stated, "Funding is needed for education to support **ongoing educational needs**, albeit less than an initial start-up," emphasizing the need for sustained financial support to maintain the educational pipelines that feed into the industry. This response highlights a broader concern that while initial funding may be in place, the ongoing financial commitment to education is necessary to ensure a steady stream of skilled workers and the development of new technologies.

Computing or Artificial Intelligence (AI)

The growing importance of computing resources and AI was another key theme. As one respondent pointed out, "Artificial Intelligence...has recently become a new and significantly important tool useful towards effectively coordinating the flow of such information." The anticipated expansion of AI's role in the industry suggests that AI will become increasingly critical in optimizing operations, managing complex data, and potentially advancing nuclear fusion feasibility. Another respondent simply stated, "**Computational resources**," indicating the foundational role that computing technology plays in both current and future operations.

Radiological Source Material

Lastly, radiological source materials, including uranium, neutrons, gamma-rays, and other radiation sources, were highlighted as essential for both current and future operations. The statement, "**Sources** of neutrons, gamma-rays, and other radiation" points to the ongoing need for reliable access to these materials, which are crucial for a wide range of nuclear applications. Additionally, respondents noted the need for "Pressure vessels, graphite, uranium conversion, and enrichment," indicating the specific materials and processes vital for maintaining and advancing nuclear technologies.

Expected Energy Consumption

While most survey respondents indicated that they **do not anticipate a significant increase** in their energy consumption, there were notable exceptions. One respondent, who is currently located out of state but **plans to relocate to Tennessee, highlighted the need for a significant increase in energy** consumption due to their future operations or expansion plans. This indicates that while many organizations may have stable or slightly increasing energy needs, key players are planning to move into the state who will require substantial energy resources to support their growth. This highlights the importance of ensuring that Tennessee's energy infrastructure can support such expansions, particularly for new entrants to the state.

In conclusion, the nuclear industry faces critical challenges in securing labor, funding, advanced computing resources, and radiological materials to support its operations and future growth. While most organizations expect stable energy consumption, new entrants' potential for significant increases underscores the need for careful planning in Tennessee's energy infrastructure. Addressing these critical resources will ensure that the state can attract and support the growth of nuclear organizations, ultimately contributing to the industry's long-term success.

Siting Considerations

When organizations in the nuclear industry consider where to site their operations, a range of factors come into play. This section summarizes the key siting considerations identified by respondents, from the need for additional space to the importance of logistics and transportation.

> *A clear majority 72% of those planning to expand or relocate to Tennessee consider proximity to other nuclear entities as "Important" or "Very Important."*

Additional Space Requirements

The majority of organizations indicated that additional space, land, or property is not critical to their current or future operations. Specifically, 34 respondents stated that additional space is "Not critical" for their short-term (1-3 years) operations, and 29 respondents felt the same about their long-term (5-15 years) needs. However, a small number of organizations do require additional space, with a few indicating needs ranging from 1 to 100 acres, particularly for long-term expansion.

Interestingly, **71%** of the respondents who indicated a critical need for additional acreage are based in Tennessee. This suggests that local organizations are likely to be the primary drivers of future growth in the state's nuclear industry.

Proximity to Other Nuclear Organizations

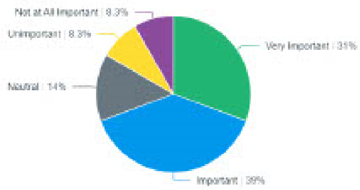
Proximity to other nuclear organizations is another significant consideration for many respondents. A clear majority—**72%** of those planning to expand or relocate to Tennessee—consider proximity to other nuclear entities as "Important" or "Very Important." This suggests that for most expanding organizations, being close to industry peers is a key factor in their siting decisions.

Connection with the Surrounding Community

Most organizations highly value maintaining a strong connection with the surrounding community. A total of 30 respondents rated this as either "Very Important" or "Important," emphasizing the significance of community engagement in their operations. None of the organizations planning to expand or relocate to Tennessee considered community connection "Unimportant," highlighting the priority placed on positive community relations for those businesses ready to grow.

Workers' Livability Factors

How important are workers livability factors, such as housing, daycare, or public transportation, affecting your siting decisions?



Livability Factors

Workers' livability factors, such as housing, daycare, and public transportation, also play a critical role in siting decisions for many organizations. The majority of respondents—**70%**—consider these factors as "Important" or "Very Important." This indicates that organizations are keenly aware of the need to support the well-being of their employees to attract and retain a skilled workforce.

Other Important Siting Considerations

When asked about other considerations in siting efforts, respondents highlighted a variety of factors. Three dominant themes emerged:

1. **Proximity (to Clients and Other Industry)**: Many organizations emphasized the importance of being close to their client base and other industry players.
2. **Taxes and Financial Considerations:** Tax incentives, such as abatements and subsidies, are significant factors in site selection.
3. **Proximity to Workforce**: Access to a skilled labor force is essential, with organizations recognizing the need to be near labor markets that can support their operational needs.

Logistics and Transportation

Special logistical concerns appear to be largely irrelevant for most organizations. The majority of respondents indicated that they do not have unique requirements for logistics and transportation.

In summary, as Tennessee continues to develop its nuclear industry, understanding and addressing these diverse siting considerations will be crucial for supporting the growth and success of organizations within the state.

Education and Workforce

Tennessee's nuclear industry's success hinges on its educational pipelines' effectiveness and the ability to attract, retain, and develop skilled talent. The following section synthesizes responses from key industry stakeholders, providing insights into current perceptions and recommendations for improvement.

Effectiveness of Tennessee's Nuclear Education Programs

When asked about the effectiveness of Tennessee's nuclear education programs in cultivating a skilled workforce, responses were mixed. The largest group of respondents rated the programs as **"Slightly Effective,"** reflecting a recognition that, while beneficial, the programs have room for improvement. A significant number of participants were "Neutral" or "Unsure," indicating a lack of strong endorsement or possibly insufficient engagement with these programs. Organizations more involved in educational pipelines were more critical, suggesting that those with closer ties to these programs see gaps that need to be addressed. These involved entities could be invaluable in guiding future improvements, as they are likely to have a clear understanding of where current programs fall short.

Critical Careers: Short-Term and Long-Term Needs

Tennessee's nuclear industry identifies several key roles as critical for both the short-term (1-3 years) and long-term (5-15 years). **Nuclear Engineers** emerged as the most crucial occupation, mentioned 33 times across both time frames. This highlights the consistent demand for this role, vital for the industry's ongoing operations and expansion.

Other significant roles include **Health Physicists**, **Radiation Protection Technicians**, **Construction Tradesmen**, and **Maintenance Tradesmen**. These occupations are critical for maintaining safety standards, constructing and maintaining facilities, and ensuring operational efficiency. Interestingly, private companies within the industry highlighted these roles as particularly vital. The consistency of these mentions underscores the importance of developing specialized skills in these areas to meet both current and future demands.

Involvement in Educational Pipelines

Despite the recognition of critical roles, there is a notable gap in involvement with educational programs. Among those who did rate Tennessee's education programs as effective, none were highly involved in the educational pipelines. This suggests that those who see the value in these programs might not be directly engaged in shaping them, potentially limiting the impact of their insights. Conversely, those who are more engaged with these pipelines expressed a need for improvement. Their feedback indicates that closer collaboration between industry and education providers could lead to more tailored and effective programs.

Improving Tennessee's Educational Pipelines

Respondents offered several suggestions for enhancing Tennessee's educational pipelines. A common theme was the need to start early, with a stronger focus on STEM (Science, Technology, Engineering, and Mathematics) education at the K-12 level. Additionally, collaboration with community colleges was also highlighted as a critical step. By aligning college programs more closely with industry needs, Tennessee could ensure that graduates are well-prepared to enter the nuclear workforce.

Attracting, Retaining, and Developing Talent

To attract and retain talent, respondents emphasized the need for visible progress and commitment within the nuclear industry. Early exposure to identify students with a passion for nuclear science and guide them through a well-supported educational pathway could help build a strong future workforce. As one respondent said, "Tennessee seems to have impressive pipelines in place, but needs to focus on recruitment of students to fill those pipelines who wish to enter the nuclear industry."

> *Tennessee...needs to focus on recruitment of students to fill those pipelines.*

Incentives, both financial and professional, were frequently mentioned. Addressing cost-of-living concerns and improving the state's overall appeal as a place to live and work were also noted as important factors. Additionally, enhancing Tennessee's image as a progressive and supportive environment for nuclear energy could further attract top talent.

The feedback from industry stakeholders provides a clear roadmap for strengthening Tennessee's educational pipelines and workforce development efforts. By focusing on early education, industry collaboration, and visible progress, Tennessee can position itself as a leader in the nuclear industry and ensure that it has the skilled workforce needed to support future growth.

Regulatory Environment

The regulatory landscape is critical to the success and growth of Tennessee's nuclear industry. Effective regulation ensures safety and quality, but it can also present significant challenges for organizations. This section examines the responses to several key questions about the regulatory environment in Tennessee.

The Cost and Burden of NQA-1 Certification

One aspect of the regulatory environment specifically asked about was the NQA-1 Certification[2]. This certification process, a critical quality assurance standard in the nuclear industry, is perceived by many as both costly and burdensome. According to the survey:

- **70%** of respondents who are subject to the NQA-1 Certification process indicated that it is "Moderately," "Very," or "Extremely Costly or Burdensome."
- The certification involves extensive documentation, time-consuming audits, and significant costs, particularly for smaller organizations.

These figures underscore the substantial impact of the NQA-1 Certification process on companies operating in Tennessee. For many, the burden of certification can divert resources away from other important areas, such as innovation and workforce development. Addressing these challenges could involve streamlining the certification process, providing financial support, or offering technical assistance to help organizations navigate the requirements more efficiently.

Tennessee's Regulatory Environment for Nuclear Technology

The overall regulatory environment in Tennessee received mixed reviews from respondents:

- **75.9%** of respondents found the environment to be either "Very Conducive" or "Conducive" to the establishment and growth of nuclear technology.
- **22%** felt it was only "Slightly Conducive," and **only one** respondent described it as "Not Very Conducive."

[2] The American Society of Mechanical Engineers, Nuclear Quality Assurance (NQA-1) Certification, https://www.asme.org/certification-accreditation/nuclear-quality-assurance-nqa1-certification

These responses suggest that while the majority of organizations view Tennessee's regulatory environment positively, while the one respondent who rated the environment as "Not Very Conducive" was not currently located in Tennessee. This indicates that these concerns may be more pronounced among companies unfamiliar with the state rather than those already established here.

Challenges in Navigating Tennessee's Regulatory Landscape

When asked about specific challenges or obstacles encountered in Tennessee's regulatory landscape, respondents provided a range of insights, which can be grouped into four key categories:

1. **Regulatory Complexity and Overlap**:
    - Respondents noted the involvement of too many agencies and regulatory bodies, which complicates the process of navigating regulations.
    - Knowing who the key players are and understanding their roles at different stages in the process were also identified as challenges.
2. **Licensing and Funding Challenges**:
    - Licensing and funding were highlighted as significant obstacles, particularly in terms of obtaining local and state regulatory support during plant expansions or new developments.
3. **Access and Infrastructure Issues**:
    - Access to national laboratories and utilities was cited as a specific challenge, indicating that infrastructure and resource availability are critical considerations for companies operating in Tennessee.
4. **No Significant Obstacles or Not Applicable**:
    - A substantial portion of respondents indicated that they did not face significant obstacles, or that the question was not applicable to their situation, suggesting that for many, the regulatory environment in Tennessee is functioning effectively.

How Tennessee Can Assist with Regulatory Compliance

Respondents offered several suggestions for how Tennessee could better assist organizations in achieving regulatory milestones or compliance. Notable responses include:

1. **Communication and Networking**:
    - Enhancing communication and networking abilities, similar to the E4 Carolinas model, was suggested as a way to improve collaboration and streamline

regulatory processes. By fostering stronger connections between stakeholders, Tennessee could help organizations navigate the regulatory landscape more effectively.

2. **Consistent Regulatory Support**:
   - Providing consistent support and thoroughly evaluating proposed regulatory changes were highlighted as critical needs. By ensuring that regulatory updates are clear and predictable, Tennessee can help companies maintain compliance without facing unexpected challenges.
3. **Investment in Education and Talent Development**:
   - Continuing to invest in education and workforce development was emphasized as a key area where Tennessee can make a difference.
4. **Early Engagement with Businesses**:
   - Early engagement with Tennessee-based businesses was identified as an important strategy for helping organizations navigate regulatory requirements.

These suggestions highlight the importance of proactive support from the state, both in terms of regulatory consistency and in fostering a strong, well-connected industry community.

The regulatory environment in Tennessee is a critical component of the state's nuclear industry, with significant implications for the success and growth of organizations operating in this sector. While many respondents view the environment as conducive to growth, there are clear challenges that need to be addressed. By focusing on these key areas will not only help organizations achieve regulatory compliance more efficiently but will also foster a more innovative and resilient nuclear sector in the state.

Nuclear Industry Incentives

Incentives are the State's commitment to supporting the industry and can significantly impact the financial viability of establishing or expanding operations. This section explores responses related to the Tennessee Nuclear Fund, the types of incentives most valued by industry stakeholders, specific federal incentives, and the cost burdens that companies face in both the short and long term.

The Tennessee Nuclear Fund: Signaling State Commitment

The Tennessee Nuclear Fund was established to demonstrate the state's commitment to supporting the nuclear industry. When asked whether the Fund sufficiently signals this commitment, responses varied, reflecting different perceptions of its effectiveness.
The responses to the question "Is the Tennessee Nuclear Fund sufficiently signaling the State's commitment to the nuclear industry?" from the survey are as follows:

- **Strongly Agree**: 23.5% of respondents
- **Agree**: 29.4% of respondents
- **Neutral**: 29.4% of respondents
- **Haven't heard of the fund**: 11.7% of respondents
- **Strongly Disagree**: 2.9% of respondents
- **Disagree**: 2.9% of respondents

A notable observation is that all respondents who were unfamiliar with the fund, as well as those who disagreed or strongly disagreed with its effectiveness, were based in Tennessee. This suggests that awareness of the Tennessee Nuclear Fund may need to be enhanced within the state, particularly among local stakeholders who could benefit from its support. Despite this, a significant portion of respondents did express agreement or strong agreement, indicating that the Fund is a positive step forward, although there is room for improvement in outreach and communication.

Effective Financial Incentives and Support Mechanisms

When asked about the types of financial incentives or support mechanisms that would be most effective in encouraging organizations to establish or expand operations in Tennessee, several key themes emerged:

1. **Tax Incentives**:
    - Tax abatements and credits were frequently mentioned as effective incentives.
2. **Direct Financial Support**:
    - Grants and low-interest loans were also highlighted as valuable tools.
3. **Support for Workforce Development**:
    - Incentives aimed at workforce training and development were considered crucial.
4. **Infrastructure Investment**:
    - Respondents also pointed to the importance of state investment in infrastructure, including utilities, transportation networks, and research facilities.

Federal Incentives Supporting the Nuclear Industry

Respondents highlighted several important federal incentives and programs that play a crucial role in supporting the nuclear industry. These include:

1. **IRA Production Tax Credits (PTCs)**:
    - The Inflation Reduction Act (IRA) includes extended and expanded Production Tax Credits for nuclear power, providing financial incentives based on the amount of electricity generated by qualifying facilities.
2. **Advanced Reactor Demonstration Program (ARDP)**:
    - The ARDP is a U.S. Department of Energy (DOE) initiative that provides funding to accelerate the development and deployment of advanced nuclear reactors. This program supports demonstration projects for new reactor designs, including small modular reactors (SMRs), which are crucial for the future of the nuclear industry.
3. **High-Assay Low-Enriched Uranium (HALEU) Incentives**:
    - HALEU is critical for many advanced nuclear reactors, and the DOE has established programs to ensure a domestic supply chain for this fuel.

These federal incentives provide critical financial support, reduce regulatory barriers, and ensure the availability of necessary resources, such as HALEU. Together, they complement state-level incentives and play a significant role in fostering the growth and innovation of Tennessee's nuclear industry.

Significant Cost Burdens in the Short and Long Term

Understanding the specific cost burdens that organizations face is key to designing effective incentives. Respondents provided examples of significant cost burdens in both the short-term (1-3 years) and long-term (5-15 years):

1. **Short-Term Cost Burdens**:
   - **Regulatory Compliance Costs**: Many respondents highlighted the costs associated with regulatory compliance, particularly the expenses related to meeting stringent safety and quality standards like the NQA-1 Certification. These costs can be a major financial strain, especially for smaller companies.
   - **Initial Capital Investment**: The high upfront costs of establishing operations, including purchasing land and equipment and securing permits, were also noted as significant short-term burdens.
2. **Long-Term Cost Burdens**:
   - **Sustained Operational Costs**: In the long term, the ongoing costs of maintaining compliance with evolving regulations, as well as the expenses associated with facility upgrades and expansions, were cited as major financial challenges.
   - **Workforce Retention and Training**: The cost of retaining and continually training a skilled workforce was another significant long-term burden.

Leveraging Federal Programs

In addition to state-level incentives, respondents emphasized the importance of leveraging current federal programs that incentivize nuclear energy. Some key points include:

1. **Federal Research Grants**:
   - Several respondents pointed to federal research grants as a critical resource for advancing nuclear technology.
2. **Department of Energy (DOE) Support**:
   - The DOE offers a range of programs that support nuclear energy, including funding for reactor design, safety research, and workforce training. Respondents emphasized the importance of actively pursuing DOE support to complement state-level incentives.
3. **Public-Private Partnerships**:
   - Federal initiatives that promote public-private partnerships were also mentioned as valuable tools. These partnerships can bring together government resources

and private sector expertise to drive innovation and growth in the nuclear industry.

Leveraging these federal programs, in conjunction with state-level incentives, can provide a comprehensive support system for nuclear companies in Tennessee.

The Tennessee Nuclear Fund is a strong signal of the state's commitment, but additional incentives, such as tax abatements, grants, and workforce development support, are needed to fully realize the state's potential as a hub for nuclear innovation. Addressing the significant cost burdens faced by companies, both in the short and long term will be key to attracting and retaining businesses.

Audience Poll from NOW

In addition to the Business and Regulatory Survey, the Business and Regulatory team sought to compare and contrast its findings with those from a separate audience poll conducted by the East Tennessee Economic Committee (ETEC) during their Nuclear Opportunities Workshop (NOW) on July 31st, 2024. The ETEC NOW conference provided a platform for real-time audience engagement, offering immediate feedback to prompt further discussion among attendees.

Poll Overview

The audience poll conducted at the ETEC NOW conference served as an interactive tool, capturing the opinions and priorities of attendees across various sectors within the nuclear industry. The audience, comprising nuclear engineers, policymakers, educators, students, and business professionals, was prompted to respond to several key questions related to economic incentives, workforce development, and the strategic importance of regional clusters and regulatory facilitation.

Key Poll Questions and Findings

1. **Economic Incentives for Locating Companies**

The first question asked attendees to identify the top three economic incentives most important to them when considering locating their company in a particular state. The options included tax incentives, grants and direct funding, subsidized loans, relocation and training grants, utility incentives, infrastructure support, regulatory flexibility, and land availability.

- Top Responses: Out of 117 respondents, the most frequently selected incentives were Infrastructure Support, Tax Incentives, and Grants and Direct Funding. This aligns with findings from the Business and Regulatory Survey, emphasizing the importance of robust infrastructure and financial support to attract nuclear businesses.

2. **Importance of a Nuclear Energy Workforce Center**

The second question gauged the importance of establishing a Nuclear Energy Workforce Center in Tennessee, focusing on collaboration, education, training, and career awareness.

- Key Insight: Of the 124 respondents, 94% considered establishing such a center to be moderately to extremely important. This reflects a strong consensus on the need for enhanced educational and training facilities, mirroring sentiments expressed in the Council's survey about workforce development needs.

3. Interest in Locating Nuclear Business in Tennessee

The third question explored whether attendees considered locating their nuclear business in Tennessee.

- Response Breakdown: Among the 97 respondents, 17% were actively planning or considering relocating to Tennessee, 6% were not considering it, and a significant 76% were already operating within the state. This shared insight from both the poll and the survey emphasizes the importance of focusing on businesses already in Tennessee and supporting their expansion through targeted incentives and a favorable regulatory environment.

4. Priorities for Workforce Development

The fourth question asked respondents to rank their top three priorities for workforce development from a list of areas identified by the Tennessee Nuclear Energy Advisory Council (TNEAC).

- Top Priorities: Out of 96 respondents, the highest-ranked priorities were Skilled Craft Workforce, Project Controls, and STEM Certifications. These priorities closely reflect the survey results, which also identified a strong need for skilled labor and specialized training programs. The consistent focus on workforce development across both the poll and the survey highlights a critical area for state intervention, particularly in expanding educational and training pipelines to meet industry demands.

5. Attractiveness of Regional Clusters and Innovation Sites

The fifth question examined the attractiveness of regional clusters of nuclear technology and mixed-use nuclear innovation sites for business operations.

- Attractiveness Ratings: Out of 96 respondents, 80% found regional clusters and innovation sites to be somewhat to highly attractive for their business. This aligns with the survey findings that emphasize the importance of proximity to other nuclear organizations for collaboration and operational efficiency.

6. **Establishment of a Regulatory and Business Development Facilitation Team**

The final question explored the potential benefits of a state-level regulatory and business development facilitation team.

- Perceived Benefits: Of the 96 respondents, 72% indicated that such a team would be somewhat or highly beneficial to their operations. This response suggests a need for streamlined regulatory processes, a theme also prominent in the Council's survey.

In conclusion, the audience poll conducted at the ETEC NOW conference provides valuable complementary insights to the Business and Regulatory Survey. Both the poll and the survey highlight common themes, such as the importance of economic incentives, workforce development, regulatory facilitation, and strategic site selection. These findings will help inform the final report and recommendations to Governor Lee as the Council continues to position Tennessee as a leader in the nuclear energy sector.

Survey Limitations

In any survey-based study, understanding the limitations of the data collection process is crucial for contextualizing the results. While the responses gathered provide valuable insights into Tennessee's nuclear industry, several limitations should be acknowledged.

Low Number of Respondents

One significant limitation of this survey is the relatively low number of respondents. Thirty-six individuals participated in this survey. Although the responses gathered offer important insights, the small sample size suggests that these insights may not fully capture the diversity of opinions and experiences within Tennessee's nuclear sector.

Missed Question Opportunities

Feedback from the survey highlighted some areas where the questions could have been deeper or more comprehensive. Two key themes emerged from this feedback:

1. **Funding Awareness and Accessibility**: Respondents suggested that the survey should have included more detailed questions about funding opportunities and the accessibility of these funds. Specifically, there was interest in understanding how businesses can better access federal and state funding, such as the Tennessee Nuclear Fund or federal grants.
2. **Nuclear Safety Culture:** Another significant area of feedback was the absence of questions related to nuclear safety culture. Given the importance of maintaining a strong safety culture within the nuclear industry, questions in this area could have helped assess how Tennessee's nuclear enterprises are addressing safety concerns and adhering to industry norms.

These missed opportunities suggest that future surveys could benefit from a broader scope and more targeted questions, particularly in areas critical to the nuclear industry's long-term success and regulatory compliance.

Conclusion

The Tennessee Nuclear Energy Advisory Council, established by Governor Bill Lee, embarked on a comprehensive mission to position Tennessee as a national leader in nuclear energy innovation and advancement. A critical element of this mission was the Business and Regulatory Survey, designed to gather essential insights from stakeholders across the nuclear industry. This survey was undertaken to explore economic opportunities, identify regulatory challenges, and assess the effectiveness of current incentives, all with the goal of ensuring that Tennessee remains an attractive destination for nuclear energy companies.

The survey, consisting of 38 detailed questions, was conducted between June 20th and August 15th, 2024. It covered a wide range of topics, including demographics, nuclear subsectors, critical resources, siting considerations, education and workforce, regulatory environment, and incentives. With the support of the East Tennessee Economic Council (ETEC) and the Tennessee Advanced Energy Business Council (TAEBC), the survey reached a diverse array of respondents, providing a comprehensive overview of the current state of Tennessee's nuclear industry.
Key findings from the survey highlighted the critical role of the private sector in Tennessee's nuclear industry, the importance of workforce development, the anticipated rise of fusion technology, and the need for enhanced educational programs and incentives. Additionally, the survey revealed mixed perceptions about the effectiveness of the Tennessee Nuclear Fund, underscoring the need for improved outreach and communication.

Respondents: The survey showed that 66.7% of respondents were private companies, with 54% being small businesses with fewer than 100 employees. This highlights the private sector's dominant role and the importance of small enterprises in Tennessee's nuclear industry.

Important Sub-Sectors: While Nuclear Power Generation remains central, there is a growing anticipation of an increase in fusion technology (50% criticality increase in 5-15 years), indicating the need for strategic investments in this emerging area.

Critical Resources: Skilled labor emerged as the most critical resource, with respondents emphasizing the importance of workforce development and targeted incentives to attract and retain talent, alongside significant investments in computing and AI technologies.

Siting Considerations: Proximity to other nuclear organizations is a key factor in site selection, with 72% of respondents considering it important, underscoring the value of industry clustering for collaboration and efficiency.

Education and Workforce: There is a perceived need for improvement in nuclear education programs, particularly among those actively involved in educational pipelines, highlighting the necessity for better alignment with industry needs.

Regulatory Environment: 75.9% of respondents say Tennessee's regulations are conducive to nuclear technology growth, while most still find certain processes, like the national NQA-1 Certification standard, to be "Costly or Burdensome" (70%), presenting opportunities to streamline. Respondents also highlighted that providing consistent regulatory support is a critical need.

Incentives: The Tennessee Nuclear Fund was known by 88.3% of industry respondents, who saw it as a positive step while also calling for additional financial incentives like tax abatements and grants to attract businesses.

These findings are consistent with the audience poll from ETEC's NOW conference in July 2024 and provide valuable insight into the industry's needs. They are also vital in informing the Council's final report to Governor Lee. Due to be submitted by October 31st, 2024, this report will provide strategic recommendations to foster Tennessee's leadership in the nuclear energy sector. The recommendations will address the industry's current needs while anticipating future developments, ensuring that Tennessee remains at the forefront of nuclear energy innovation, economic growth, and energy independence.

The Business and Regulatory Survey has provided invaluable insights that will guide the Council in shaping policies and strategies to support and expand Tennessee's nuclear industry. By leveraging these findings, Tennessee can continue to build a robust nuclear energy ecosystem that benefits the state and contributes to the nation's energy future.

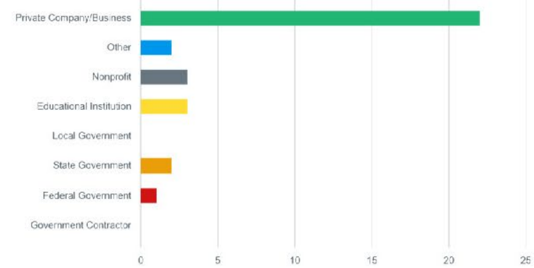
Appendix 1: List of Survey Questions.

1. Which category best describes your organization?
2. Which sectors of the nuclear industry does your organization work in (choose all that apply)?
3. Does your organization have a physical presence in Tennessee?
4. Is your organization interested in expanding or relocating to Tennessee?
5. How many employees does your organization have?
6. How does your organization compare to the Tennessee Annual Average Occupational Wage?
7. How long has your organization operated in the nuclear field?
8. What is the most critical nuclear sub-sectors to your current or short-term (1-3yr) operations? (choose up to three)
9. What is the most critical nuclear sub-sectors to your future operations or expansion (5-15yr)? (choose up to three)
10. Why are these sectors important to your operations?
11. What specialized equipment, resources, or components are most critical to your current or short-term (1-3yr) operations, and why?
12. What specialized equipment, resources, or components are most critical to your future operations or expansion (5-15yr), and why?
13. Please name a resource, or resources, your organization relies on that is difficult to acquire, hard to access, or susceptible to very volatile markets.
14. How much do you anticipate your energy consumption will need to increase due to your future operations or expansion (5-15yr)?
15. Is additional space, land or property, critical to your current or short-term (1-3yr) operations, and if so, how much?
16. Is additional space, land or property, critical to your future operations or expansion (5-15yr), and if so, how much?
17. How important is the physical proximity to other nuclear organizations factor into your siting decisions?
18. How important is it for your organization to have a strong connection with its surrounding community?
19. How important are workers' livability factors, such as housing, daycare, or public transportation, affecting your siting decisions?
20. What other considerations are important in your organization's siting efforts?

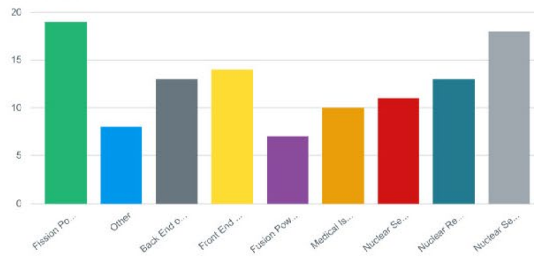
21. Does your organization have unique requirements for logistics and transportation, and if so, what are they?
22. How effective are Tennessee's nuclear education programs at cultivating a skilled workforce and meeting your organization's labor needs?
23. What skills, vocations, or careers are must critical to your current or short-term (1-3yr) operations? (choose up to three)
24. What skills, vocations, or careers are must critical to your future operations or expansion (5-15yr)? (choose up to three)
25. How involved is your organization in the current education pipelines that feed the skills and careers your organization depends on?
26. How can Tennessee improve its educational pipelines to train the workforce to meet labor demands?
27. In what ways do you think Tennessee can improve its efforts to attract, retain, and develop talent relevant to the nuclear industry?
28. How costly or burdensome do you find the NQA-1 Certification process for your company?
29. If you selected "Moderately," "Very," or "Extremely Costly or Burdensome," please indicate which aspects of the NQA-1 Certification process you find most burdensome.
30. To what extent do you believe the current regulatory environment in Tennessee is conducive to the establishment and growth of nuclear technology?
31. What specific challenges or obstacles do you encounter when navigating the regulatory landscape for nuclear technologies in Tennessee?
32. How can Tennessee assist your organization in achieving regulatory milestones or compliance?
33. Is the Tennessee Nuclear Fund sufficiently signaling the State's commitment to the nuclear industry?
34. What types of financial incentives or support mechanisms would be most effective in encouraging your organization to establish or expand operations in our state?
35. Please give an example of a significant cost burden that affects your current or short-term (1-3yr) operations.
36. Please give an example of a significant cost burden that affects your future operations or expansion (5-15yr).
37. Are there current, former, or proposed incentive programs outside of Tennessee that could be replicated or adopted in our state, and if so, which?
38. Are there current programs, such as federal grants, that incentivize nuclear energy that the State and/or organizations can actively take advantage of, and if so, which?

Appendix 2: Survey Result Graphs.

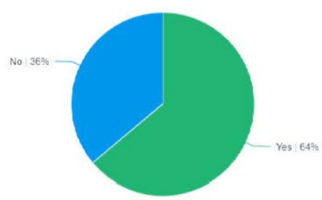
Which category best describes your organization?



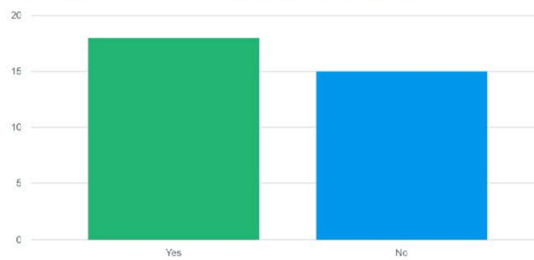
Which sectors of the nuclear industry does your organization work in (choose all that apply)?



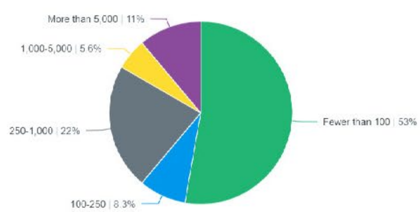
Does your organization have a physical presence in Tennessee?



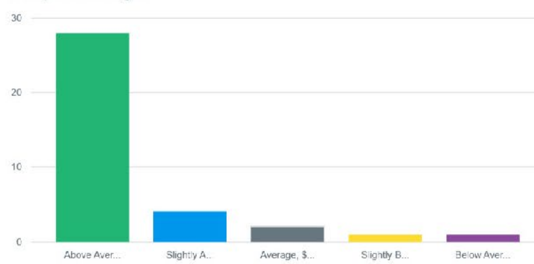
Is your organization interested in expanding or relocating to Tennessee?



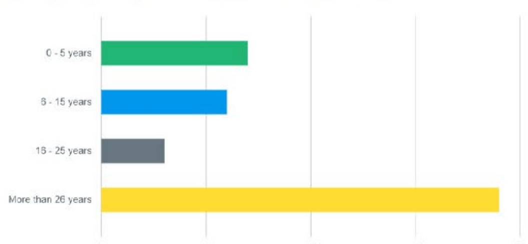
How many employees does your organization have?



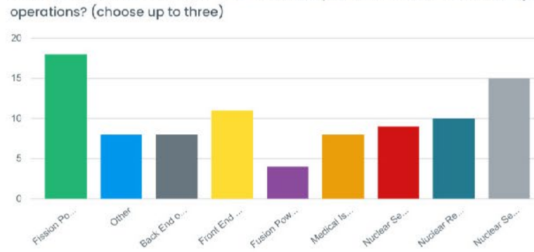
How does your organization compare to the Tennessee Annual Average Occupational Wage?



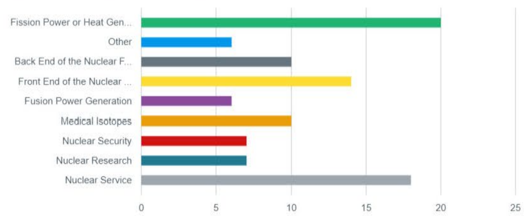
How long has your organization operated in the nuclear field?



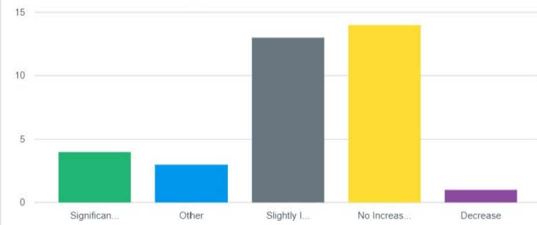
What is the most critical nuclear sub-sectors to your current or short-term (1-3yr) operations? (choose up to three)



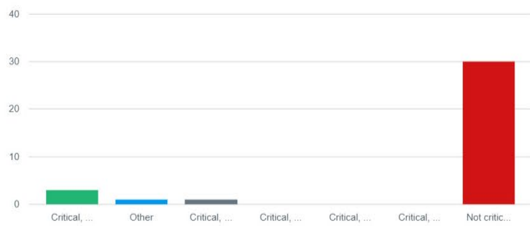
What is the most critical nuclear sub-sectors to your future operations or expansion (5-15yr)? (choose up to three)



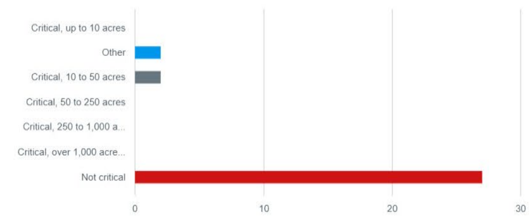
How much do you anticipate your energy consumption will need to increase due to your future operations or expansion (5-15yr)?



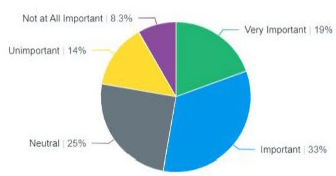
Is additional space, land or property, critical to your current or short-term (1-3yr) operations, and if so, how much?



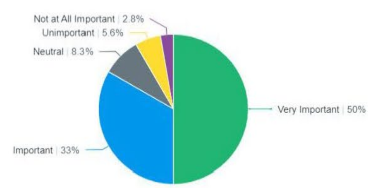
Is additional space, land or property, critical to your future operations or expansion (5-15yr), and if so, how much?



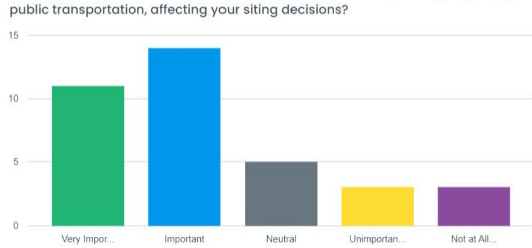
How important is the physical proximity to other nuclear organizations factor into your siting decisions?



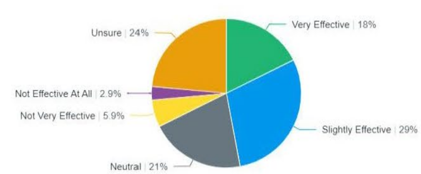
How important is it for your organization to have a strong connection with its surrounding community?



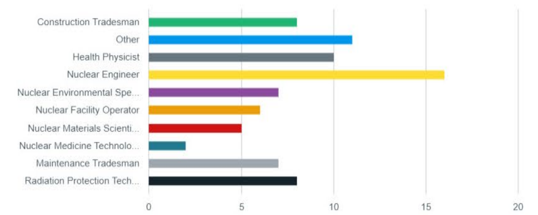
How important are workers' livability factors, such as housing, daycare, or public transportation, affecting your siting decisions?



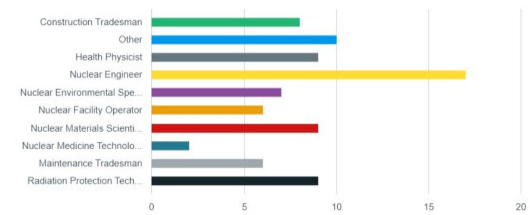
How effective are Tennessee's nuclear education programs at cultivating a skilled workforce and meeting your organization's labor needs?



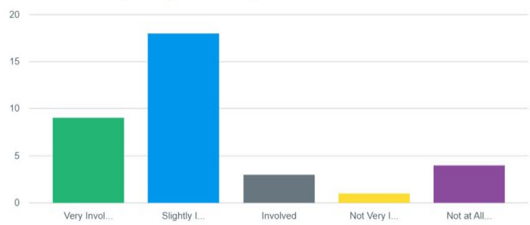
What skills, vocations, or careers are must critical to your current or short-term (1-3yr) operations? (choose up to three)



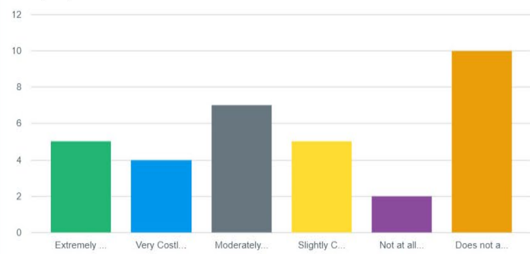
What skills, vocations, or careers are must critical to your future operations or expansion (5-15yr)? (choose up to three)



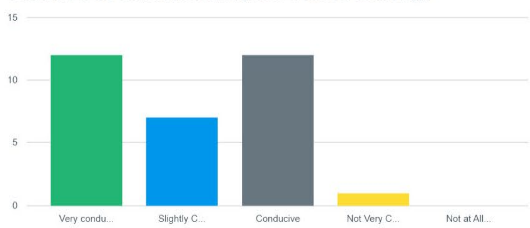
How involved is your organization in the current education pipelines that feed the skills and careers your organization depends on?



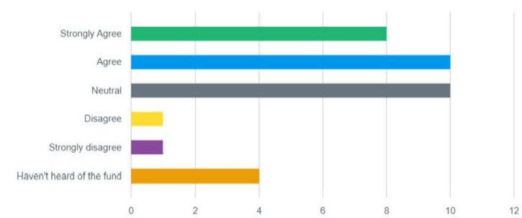
How costly or burdensome do you find the NQA-1 Certification process for your company?



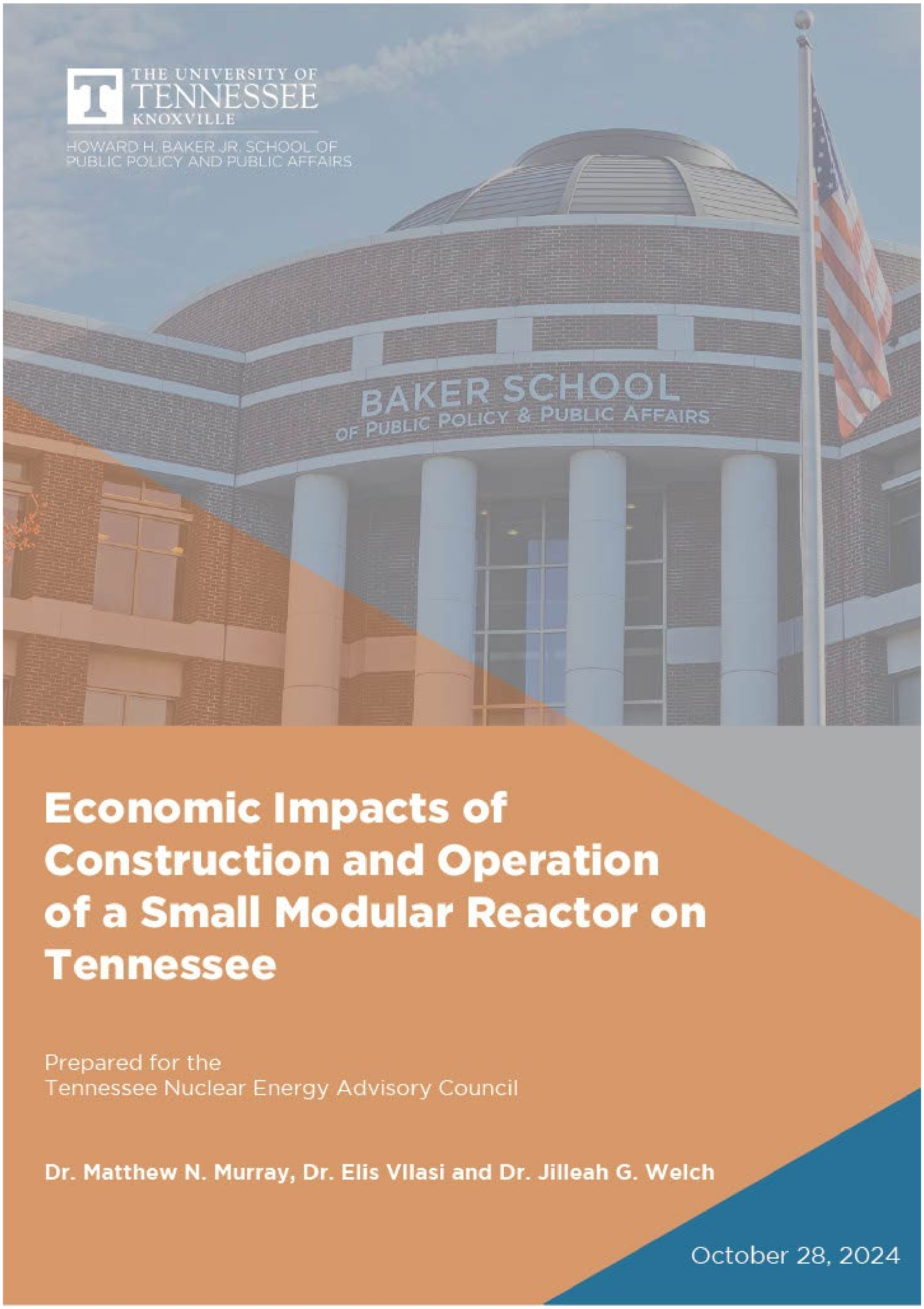
To what extent do you believe the current regulatory environment in Tennessee is conducive to the establishment and growth of nuclear technology?



Is the Tennessee Nuclear Fund sufficiently signaling the State's commitment to the nuclear industry?



Appendix C: Economic Impacts of Construction and Operation of a Small Modular Reactor on Tennessee - University of Tennessee Baker School of Public Policy and Public Affairs



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Economic Impacts of Construction and Operation of a Small Modular Reactor on Tennessee

Prepared for the

Tennessee Nuclear Energy Advisory Council

Prepared by

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Scope
Economic Impacts of Construction and Operation of a Small Modular Reactor on Tennessee

The Tennessee Nuclear Energy Advisory Council (TNEAC) identified supporting TVA's deployment of a small modular reactor at the Clinch River Nuclear site as a priority in our Preliminary Report (December 2023). To that end, the TNEAC commissioned the University of Tennessee Baker School of Public Policy & Public Affairs to produce an assessment on the *"Economic Impacts of Construction and Operation of a Small Modular Reactor in Tennessee*." The findings of the Baker School's SMR Economic Impact Assessment (EIA) follow here and provide valuable information to the TNEAC as it drafts its Final Report to be delivered by October 31, 2024.

This EIA estimates an SMR (300 MW) deployed in Tennessee would generate $1.4 billion in construction spending directly sourced from within the state. Netting out employment benefits and taxes on worker payroll, $1 billion in spending would spread through supply chains and create a multiplying ripple effect across Tennessee. This would facilitate 16,440 new jobs (or 1,827 jobs per year) and increase the total production of goods and services in the state by $1.6 billion, or $175.2 million annually. Annual operational costs of the SMR would generate $98.5 million in yearly output for Tennessee and 717 jobs per year.

This EIA reflects best construction cost projection for a 60% complete SMR design. The EIA has greater confidence in the model and multiplier to estimate economic impacts to output (GDP), income, and jobs. For $1 billion in in-state construction spending on goods and services, this EIA projects Tennessee's output (GDP) grows by $1.6B. This economic impact figure is largely scalable. If actual *in-state* construction cost increases, the impact would be roughly expected to increase according to that 1.6:1 ratio, e.g., if construction cost is $2 billion, then then economic impact for Tennessee would be close to $3.2 billion.

While an increase to generation capacity would be an important net benefit of the SMR deployment, this EIA focuses specifically on economic impact of output, income, and jobs from the construction and ongoing operation of an SMR. It is important to note that this EIA is not a comprehensive evaluation of all the benefits that would arise from deploying an SMR in Tennessee, such as:

- The addition of reliable, resilient, safe, clean baseload power for 40 years or more and annual generation sales realized.
- Strategic value of building the first SMR would address "First of A Kind" (FOAK) costs and set the stage for ideal cost reduction, up to 40% per unit, as additional SMRs are built.
- Supply chain opportunities for Tier 1-3 suppliers locating or expanding in Tennessee for manufacturing or fabricating components for SMR deployment in Tennessee. EIA offers guidance in approaching GE-Hitachi and TVA to discuss opportunities and expectations for growing in-state spending on goods and services during construction of an SMR in Tennessee as well as any subsequent units.

- Potential for premium pricing schedule or agreements for SMRs' carbon-free power from particular purchasers (e.g., data centers, hyperscalers, etc.)
- Effects of first and future SMRs attracting talent, R&D/tech transfer, wraparound knowledge, capital, and community support to benefit the region's nuclear ecosystem, further demonstrating that Tennessee is a hub for nuclear development, manufacturing, and deployment.

The EIA highlights the output, income, and jobs impact from the construction and operation of an SMR in Tennessee - important aspects contributing to the overall benefits arising from such a deployment. While this EIA is not a full calculation of benefits, it demonstrates that there is significant value in deployment and provides material information for the TNEAC. It may also offer useful insights for other decision-makers, such as the TVA Board and interested stakeholders.

Executive Summary

Tennessee has strong roots in the nuclear sector, dating back to the era of the Manhattan Project. Today, Tennesseans rely on nuclear power for a significant share of their baseload electricity generation. Nuclear related research and other activities, from nuclear medicine to legacy site cleanup and waste remediation, represent important assets of the East Tennessee economy. This foundation has the potential to support the next generation of electric power supply through the construction and deployment of small modular reactors (SMRs). SMRs and nuclear power generation have the capacity to provide clean energy and help meet the nation's ongoing decarbonization goals and energy security needs while also providing widespread economic development benefits.

This report, prepared by the University of Tennessee Baker School of Public Policy and Public Affairs, documents the potential economic impacts from the construction and operation of one SMR on the Clinch River, a joint initiative of the Tennessee Valley Authority (TVA) and GE-Hitachi. While the project remains in the planning stage with no firm commitment to move forward, all the necessary steps are being taken to prepare for the actual construction of the facility. The BWRX300 would be the first SMR to be built and operated in the U.S. Construction preparation would commence in 2024, with completion slated for 2032, at which time the facility would become operational.

The impact estimates here are based on confidential data from TVA and include $1.4 billion in construction spending incurred directly (i.e., sourced) in Tennessee, a figure that includes employment benefits and some state and federal taxes. Netting these latter components out translates to $1.0 billion in spending that would spread through supply chains and create multiplier impacts as spending ripples across the state. Operational spending would support ongoing impacts through nonpayroll spending, payroll spending, and employment. The modeling presented here captures the economic impacts on state output (gross domestic product), labor income, and jobs in Tennessee.

The analysis reveals substantial multiyear impacts from construction:

- Total production of goods and services (state gross domestic product or *output*) would increase by $1.6 billion or $175.2 million per year,
- Income accruing to workers in Tennessee would total $1.4 billion or $151.5 million a year, and
- Total person-year employment would represent 16,440 jobs or 1,827 full-time jobs per year.

The impacts from operations are expressed in terms of a representative year of facility operation using 2033 as the base year.

- Deployment would support 717 jobs, with 205 tied directly to operations,
- Income for Tennesseans tied to new employment opportunities would total $56.9 million per year, and
- Total new output for the state economy would be $98.5 million a year.

Additional benefits would accrue to Tennessee through a number of channels, including increased in-state sourcing of construction materials, multiple SMR builds and deployments, spillovers to related sectors (nuclear medicine, waste remediation), and additional research, development, demonstration, and deployment (RDD&D) and partnerships with universities and private industry.

Introduction

Enthusiasm continues to grow regarding the prospect of a renewed domestic focus on nuclear power. Primary drivers are the energy transition and the need for a clean source of electric power to replace fossil fuels along with growing demand from sources including artificial intelligence. The primary headwind to nuclear adoption is cost and the need for a multi-decade payback period on investment. Because baseload energy demands cannot be completely met today by renewables, nuclear power offers a compelling alternative. In addition, reaching net zero (i.e., balancing emissions production with emissions removal) will require clean electricity and today there are few alternatives to nuclear power.

Enthusiasm for nuclear power is also driven by interest in potential economic development impacts, including job and income creation, support of critical supply chains, RDD&D, and synergies that spillover to related activities like nuclear medicine. R&D and spillover benefits are likely unique to nuclear power compared to other mature generating technologies. Domestic security and energy security concerns have also sparked interest in nuclear power options and alternatives.

SMRs are an important piece of the modern nuclear energy profile that appears to be emerging in the U.S. and abroad. SMRs are generally viewed as safe, capable of meeting both baseload and niche energy supply needs, offer siting flexibility, and can help balance overall loads across the distribution network. Because they are modular, they lend themselves to simpler manufacturing, production, and installation processes. Modularity is especially important to economic development impacts since multiple units and their component parts could be sourced from areas with unique expertise and capacity.

Tennessee and the Tennessee Valley Authority (TVA) are well-placed to play a leading role in America's potential nuclear renaissance. Currently under consideration is the construction and deployment of up to four SMRs through a partnership between TVA and GE-Hitachi, which owns the technology under consideration (BWRX300). The nuclear industry's existing economic impact in the state is already impressive and includes $9.8 billion in economic output, $3.2 billion in labor income, and over 40,000 jobs.[1] According to the East Tennessee Economic Council (ETEC) – a leading voice for the state's nuclear sector – there are more than 350 nuclear locations in the state, with 229 nuclear companies. While 154 are located in the Knoxville metropolitan area, the jobs are spread across the state with concentrations in all of Tennessee's major metropolitan areas.[2] The nuclear industry in the state benefits from the presence of numerous private businesses, including Kairos Power, TRISO-X, Ultra Safe Nuclear Corporation, and Type One Energy, that focus on advanced reactor technology, advanced nuclear fuel, pilot fuel manufacturing, and fusion energy technology. There is also a robust presence of federal agencies in East Tennessee (e.g., Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12), Oak Ridge Associated Universities (ORAU)) and institutions of higher education across the state (e.g., the University of Tennessee and its highly ranked Department of Nuclear Engineering, Tennessee Technological University, Chattanooga State Community College, Roane State Community College, Vanderbilt University). Together, these and other assets offer an extraordinarily strong foundation to build upon to support the state's energy independence and national energy security through the construction and operation of SMRs.

The estimates presented here indicate significant economic impacts from TVA's potential investment in SMR construction and deployment. Total employment impacts from the construction of a single SMR are estimated to be 16,440 person-year jobs or 1,827 full-time jobs per year. Operational-year direct employment by TVA of 205 workers will support 512 additional jobs through supply chains and the multiplier process, yielding a total employment of 717 for a representative year of facility activity. Substantial impacts would also be created for state gross domestic product (GDP) and income for Tennesseans.

The remainder of this report provides details on the statewide economic impact estimates associated with the construction and deployment of an SMR on a site on the Clinch River in East Tennessee. The discussion starts with a background on SMRs. Economic impact methods and impact estimates are subsequently presented. The report then discusses several unique facets of the SMR project that are important to framing the impact estimates. A brief conclusion closes the report.

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1 Joseph Von Nessen and Lukas Brun, "The Economic Impact of the Nuclear Industry in the Southeast United States, A Regional and State-Level Analysis," E4 Carolinas. February 2024. Estimated impacts account for direct, indirect, and induced effects that are discussed in the economic impact modeling section below.

2 ETEC has assumed a prominent role in supporting the region's nuclear sector, with a strong emphasis on much needed workforce training and development. See, for example, https://www.eteconline.org/nuclear-industry-hub/ This link also provides a map of the nuclear companies in Tennessee.

A Primer on SMRs

There are various definitions for SMRs that cover a range of sizes and reactor technologies. Generally, SMRs are distinguished from the very small class of reactors known as microreactors, which typically produce 10s of megawatts of electricity (MWe), but they are smaller than the traditional light water reactor, which produces around 1000 MWe. A further distinction is that the current fleet of operating reactors is used only to make electricity, whereas some SMRs can be used to produce industrial high-temperature heat in addition to making electricity. According to the International Atomic Energy Agency's definition,[3] SMRs are "advanced nuclear reactors that have a power capacity of up to 300 megawatts of electricity (MWe) production per unit." They are small as they are about one-third the size of traditional nuclear reactors; modular since their major components can be factory constructed, assembled, and transported to a site for installation; and recognized as reactors, since they use nuclear fission to produce energy. In other words, a "small modular reactor uses energy from a controlled nuclear chain reaction to create steam that powers a turbine to produce electricity."[4] Figure 1 provides one illustration, though this does not correspond precisely to the technology of the BWRX300 discussed below.

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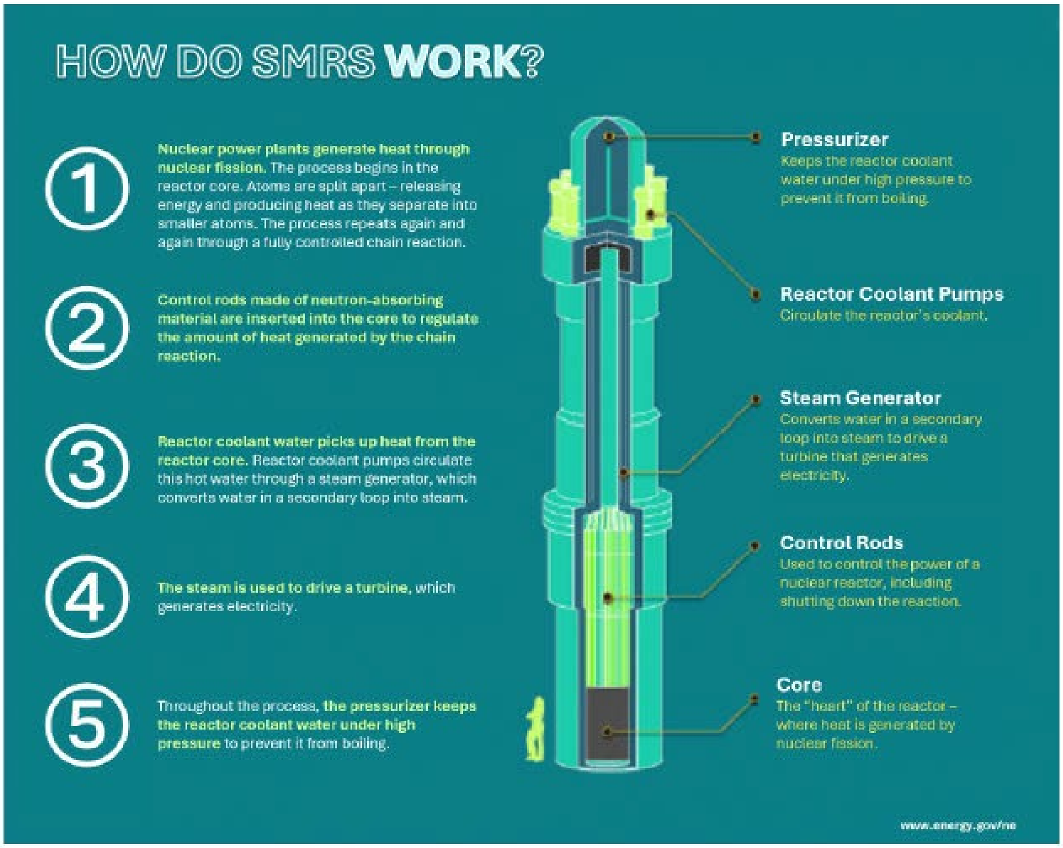
[3] Joane Liou, "What are Small Modular Reactors (SMRs)?", IAEA Office of Public Information and Communication. https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs

[4] Idaho National Laboratory, "What are Small Modular Reactors?" https://inl.gov/trending-topics/small-modular-reactors/

Figure 1. A Snapshot: How Do SMRs Work?



Source: Office of Nuclear Energy, U.S. Department of Energy

Within the range of power generation output, SMRs can be further broken down into different sizes to serve different power needs. EnerData defines three categories[5]:

1. *5-15MW* – also known as *micro-reactors* used for off-grid applications
   - Isolated communities, military and defense use, natural disaster response
2. *15-200 MW* – for heat and/or electricity in energy-intensive industrial sites
   - Desalinization, mines, O&G extraction, hydrogen production
3. *200-400 MW* – for network-connected power generation
   - Replacement of coal-fired power plants, electrification of medium-sized cities and isolated industrial centers, networks with insufficient capacity for higher power plants

What are the Different SMR Designs? In addition to varying power output, SMRs also differ in terms of design. While figures vary, EnerData lists 83 SMR designs in development, spanning Generation II (Gen II) to Generation IV (Gen IV), across 18 countries.[6] Gen II designs are older models; Gen IV models share modern features generally related to simplified design and increased passive safety. According to an American Academy of Arts and Sciences report,[7] Gen II nuclear reactors, typically known as light water reactors (LWRs), are commercial reactors designed to be economical and reliable with a lifetime of 40 years. Operating since the 1960s, they primarily include pressurized water reactors (PWR), boiling water reactors (BWR), advanced gas-cooled reactors (AGR),[8] and constitute the bulk of nuclear reactors in use today. A distinguishing feature of Gen II reactors is that they use traditional active safety features involving electrical or mechanical operations that can be initiated automatically or by the operators of the nuclear reactors.

Gen III reactors built on Gen II with state-of-the-art improvements in fuel technology, thermal efficiency, modularized construction, safety systems (especially the use of passive systems), and standardized design with a 60-year operational life. Gen III+ designs include significant improvements in "passive safety features that do not require active controls or operator intervention but instead rely on gravity or natural convection to mitigate the impact of abnormal events."

Gen IV refers to a number of nuclear reactor technologies that are still in the conceptual or prototype phase, with wide adoption and deployment still decades away.[9] Gen IV build on Gen III+ units, including

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[5] EnerData, "An Emerging Technology Backed by Public Policies." https://www.enerdata.net/publications/executive-briefing/smr-world-trends.html
[6] Ibid. EnerData.
[7] Steven M. Goldberg and Robert Rosener, American Academy of Arts & Science, Nuclear Reactors: Generation to Generation. nuclearReactors.pdf (amacad.org)
[8] Gen II reactors also include: CANada Deuterium Uranium reactors (CANDU) and Vodo-Vodyanoi Energetichesky Reactors (VVER).
[9] There is only one Gen IV reactor (HTR-PM) that is operational and is found in China. World Nuclear News, December 6, 2023, China's demonstration HTR-PM enters commercial operation : New Nuclear - World Nuclear News (world-nuclear-news.org)

the ability to support industrial processes (e.g., hydrogen production, water desalination).[10] The designs include reactors that are gas-cooled fast, lead-cooled fast, molten salt, sodium-cooled fast, supercritical water-cooled, or very high-temperature gas. [11] The Gen IV designs must also improve on Gen III+ in terms of sustainability, economics, safety and reliability, and non-proliferation.

The reactor designs vary by fuel, coolant, use, and size:

- Land-based Water-Cooled: 25 designs
- Marine-based Water-Cooled: 8 designs
- High-Temperature Gas-Cooled: 17 designs
- Liquid Metal Cooled Fast Neutron Spectrum: 8 designs
- Molten Salt: 13 designs
- Micro-Reactors: 12 designs

Only two SMR designs are currently operational, and both are based on older technologies. One SMR is in Russia, a 70 MW Russian KLT-40S by JSC Afrikantov OKBM, Pressurized Water Reactor (PWR), which is a Gen II design. China has built two SMRs. One is in operation, a 210 MW Chinese HTR-PM by Tsinghua University, High Temperature Gas Reactor (HTGR), which is a Gen II design, and the other one is an operable demonstration unit, the 2.5 MW HTR-10, HTGR, a Gen IV design.

Of all SMRs currently in development, "[t]he USA leads in terms of … design recorded (22 different designs), followed by Russia (17), China (10), Japan (5), Canada (5), and the UK (4)." It is not clear how this proliferation of models affects the adoption choice. On the one hand, the variety offers competition and opportunities for novel designs, but the same variety may create uncertainty about moving forward, especially for first adopters.

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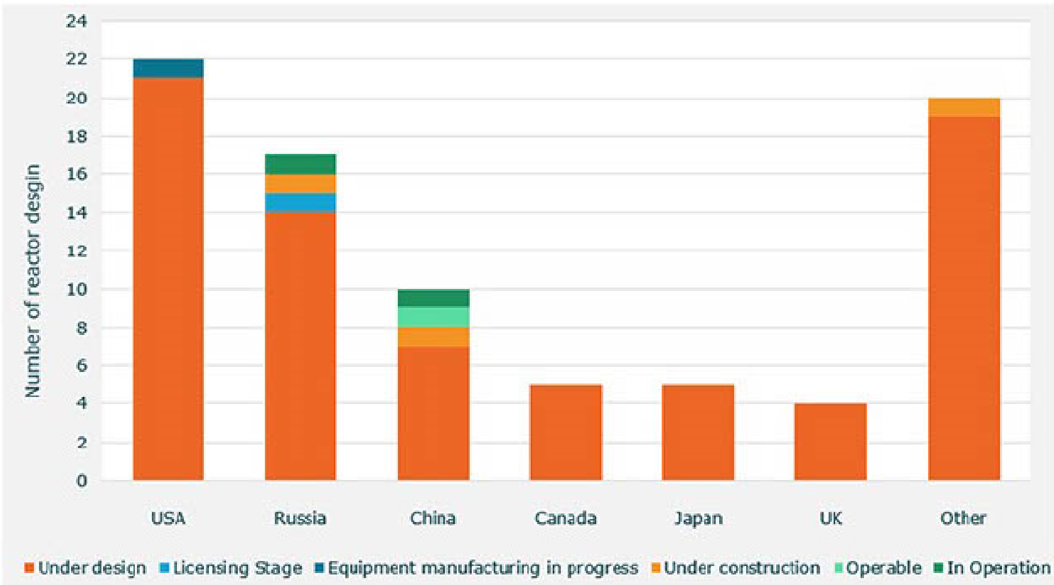
[10] Goldberg and Rosner, nuclearReactors.pdf (amacad.org)
[11] Nuclear: what is a 4th generation reactor? - Polytechnique Insights (polytechnique-insights.com)

Figure 2. Worldwide SMR Reactor Designs by Country of Origin (2022)



Source: IAEA, 2022; Enerdata 2024

The U.S. SMR designs include six land-based water-cooled, five high-temperature gas-cooled, one liquid metal-cooled, five molten salt, and five micro-reactors.[12]

What Are the Key Advantages of SMRs? Small modular reactors offer key advantages relative to traditional nuclear power plants.

- *Modularity:* For some designs, modularity allows SMRs to expand the power output by adding modules, decreasing power output by shutting off modules, and making repairs without shutting down the whole plant.
- *Standardization:* The smaller size and modularity of the nuclear reactors allow for standardization and in-factory manufacturing and shipping of major components to the construction site.
- *Configurability*: SMRs can be customized depending on location, installed into an existing grid or remain off-grid, or be built on an existing coal power plant footprint.
- *Reliability and Efficiency*: SMRs can achieve the same efficiency and high reliability that the current fleet of nuclear reactors are providing.

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[12] International Atomic Energy Agency, "Advances in Small Modular Reactor Technology Development," (2022 Edition). https://aris.iaea.org/Publications/SMR_booklet_2022.pdf

- *Functional Flexibility*: SMRs can support residential or industrial needs with district or process heating.
- *Operating Flexibility*: SMRs can complement renewables by providing load-following functions, currently performed by fossil-fueled plants, to promote grid stability.
- *Siting Flexibility*: SMRs require only 10 percent to 25 percent of the land area of a traditional nuclear plant.[13] GE-Hitachi Nuclear Energy claims that its GE-Hitachi BWRX300 – a model TVA is evaluating for potential, future deployment – achieves about 90 percent volume reduction in plant layout.[14] Moreover, some SMRs can be built near urban centers and away from large bodies of water.
- *Safeguards and Security*: Some SMRs can be installed underground, which can lower the risk of sabotage or natural hazards. As most major components are built in a factory, some SMR reactor cores (limited to microreactor designs) can be returned to the factory with the reactor vessel for defueling. The reactors are built with various passive safety features, including steam condensation and gravity, that allow cooling for extended periods (weeks to months) without power or operator action. Safety is often further enhanced by a simpler reactor design, lower core power, and/or larger fractions of coolant.
- *Lower Capital Investment and Operating Costs*: Relatively lower costs are expected due to smaller size, a shorter construction period, modular construction, and factory fabrication. SMRs may also offer economies of scale due to factory production of multiple units, easier decommissioning processes, reduced operating staff, reduced refueling needs (more operational time), and lower cooling requirements.
- *Enhanced Economic Development*: Construction and operation of an SMR produces economic impacts like new jobs and an expanded tax base that are of value to the host community and state. In addition, unlike singular large capacity generation facilities, SMRs can yield economic development benefits through *ongoing* production and parts manufacture. The attraction is the potential to produce and export multiple SMR units as well as their component parts. Additional benefits arise from related supply chains, facility deployment and management expertise, and R&D that supports nuclear advancement.

What SMR Design is TVA Considering? One SMR design that TVA is evaluating is the GE-Hitachi BWRX300 small modular reactor for potential, future deployment at the Clinch River Nuclear Site.[15] The reactor is designed by GE Hitachi Nuclear Energy (GEH), under a Technology Collaboration Agreement with TVA,

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[13] Idaho National Laboratory, "Advanced Small Modular Reactors." https://inl.gov/trending-topics/small-modular-reactors/
[14] GE Hitachi Nuclear Energy, "BWRX-300 Small Modular Reactor." https://www.gevernova.com/nuclear/carbon-free-power/bwrx-300-small-modular-reactor
[15] For more information on the TVA proposal see https://www.tva.com/energy/technology-innovation/advanced-nuclear-solutions

Ontario Power Generation (Canada) and Orien Synthos Green Energy (Poland), and will be constructed from parts and materials sourced from the U.S., Canada, and Europe. This reactor is a *Generation III+* design (a modernized version of a light water reactor, in this case, a Boiling Water Reactor with passive safety features), a land-based water-cooled reactor, and is capable of supplying electricity to the grid and electricity and/or steam for process heat applications, district heating, and hydrogen production. According to GE, the BWRX300 reactor is based on a U.S. NRC-licensed, 1,520 MWe Economic Simplified Boiling-Water Reactor (ESBWR) and incorporates the 10th evolution of boiling water reactors since GE began developing nuclear reactors in 1955.[16]

The key features of the reactor include:

- *Design Type*: Boiling Water Reactor (BWR)
- *Coolant*: Light water
- *Power*: 300 MWe (electricity output) / ~900 MWth (thermal/steam output)
- *Power Capacity to the Electric Grid*: 285 – 315 MWe / In-house use: ~15 MWe
- *Operation Cycle*: 12–24 months / 10-20 days outage per cycle
- Design (Plant) Life: 60 - 80 years
- *Building Size*: ~ 2.1 acres
- Fenced Plant Area: ~ 6.5 acres
- Total Operating Staff: ~70[17]
- *Material & Equipment Overnight Capital Costs*: $1 billion (1st unit), $750 million (nth unit), with costs continuing to change over time

To date, this reactor has been selected for pre-licensing/permit application/deployment in Canada, Poland, the UK, and the U.S. This multi-country commitment has enabled technical collaboration among GEH and multiple power providers, including TVA, Ontario Power Generation (Canada) and Synthos Green Energy (Poland), and ~ $400 million investment in the design and development of a standard reactor that is deployable in these countries and beyond.

The BWRX300 unit provides numerous advantages, according to GEH.[18]

- *Safety*: a design that mitigates large Loss-of-Coolant Accidents (LOCAs) due to "simpler passive safety systems and a more integrated Nuclear Steam Supply System compared to prior Light Water

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[16] U.S. Nuclear Regulatory Commission, "Issued Design Certification – Economic Simplified Boiling-Water Reactor (ESBWR)." https://www.nrc.gov/reactors/new-reactors/large-lwr/design-cert/esbwr.html
[17] GE Hitachi Nuclear Energy, "BWRX-300 General Description," December 2023, Table 19-2. https://www.gevernova.com/content/dam/gepower-new/global/en_US/images/gas-new-site/en/bwrx-300/005N9751_Rev_BWRX-300_General_Description.pdf. Also see "Status Report – BWRX-300 (GE Hitachi and Hitachi GE Nuclear Energy)," September 30, 2019, table 2. https://aris.iaea.org/PDF/BWRX-300_2020.pdf
[18] GE Hitachi Nuclear Energy, "BWRX-300 one of the most economical SMR designs available." https://www.gevernova.com/content/dam/gepower-new/global/en_US/images/gas-new-site/en/bwrx-300/GEA34170A-GE-Hitachi-BWRX-300-Factsheet-R7.pdf

Reactor (LWR) designs." As it uses "natural circulation and passive cooling isolation condenser systems," the unit "passively cools itself for seven days without power or operator action during abnormal events, including station blackout. Indefinite cooling is achieved by the simple action of water addition to the isolation condenser pools."

- *Savings*: the scale and simplicity of the reactor (compared to larger/other SMRs) is projected to have up to "60% less capital cost per MW when compared with other typical water-cooled SMRs," as well as "significant reductions in operating staff, maintenance cost, and security requirements." It "can be constructed in 24-36 months utilizing modular and open-top construction techniques proven in Japan."
- *Supply-Chain*: The key reactor components and the systems will be manufactured across the U.S. and allied countries (Canada, Europe, Japan), offering a more secure and greater quality supply chain and the assurance of competitive pricing.

How Secure are SMRs? Expectations are that SMRs offer greater physical security due to their inherent designs and reduced site area compared to large nuclear plants. However, any SMR, like all pieces of modern technology, will incorporate digital equipment that may be connected to communication networks (whether wireless or wired). Such digital and connected systems could make SMRs vulnerable to cyber threats like any generating asset. In 2022, there were more than 800,000 cyber-attacks in the U.S.,[19] with many significant breaches conducted by hostile states (e.g., China, Russia, Iran) and non-state actors against critical infrastructure.

An international workshop on SMR security convened by the World Institute for Nuclear Security concluded that "[n]o clear guidelines exist regarding SMR security. Developers are not sure where the boundaries are or how much protection is necessary for their designs." A key conclusion is that "cybersecurity risks are manageable."

How Much Does an SMR Cost? The cost estimates for SMR construction vary widely because of many considerations, including variation in design and, most importantly, the fact that there is no track record to build on. Projected costs appear to be much higher today than just a few years ago. A 2021 report asserts that the first-of-a-kind (FOAK) Levelized Cost of Electricity (LCOE)[20] for SMRs is $98/MWh for investor-owned utilities and $76.7 /MWh for municipal-owned utilities, with no government partnerships. With government partnerships (for example, loan guarantees), LCOE costs fall to $48.4 and $43.4 /MWh for investor and municipal-owned utilities, respectively.[21] The same report claims overnight capital costs (OCC)

[19] USA Facts, "How many cyberattacks occur in the US?" https://usafacts.org/articles/how-many-cyber-attacks-occur-in-the-us/

[20] See, for example, U.S. Energy Information Agency, "Levelized Costs of New Generation Resources in the *Annual Energy Outlook 2022*," March 2022, https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

[21] SMR Start, "The Economics of Small Modular Reactors." March 2021. http://smrstart.org/wp-content/uploads/2021/03/SMR-Start-Economic-Analysis-2021-APPROVED-2021-03-22.pdf

of $3,800 kW for an SMR facility size of 600MWe with a construction period of 36 months and a deployment year of 2030.

A 2024 study by the Institute for Energy Economics and Financial Analysis finds that SMRs are expensive and that the estimated costs are rapidly rising.[22] The study examined the rising costs of traditional reactors (Georgia Power Vogtle, Units 3 and 4) as well as SMRs (NuScale, X-Energy, and GE Hitachi BWRX300) and found that the actual costs were significantly higher than the estimated costs at the design stage. For example, the projected costs for the NuScale SMR in 2015 were $9,964/kW, but by 2023, those projected costs had ballooned to $21,561/kW. The same trend holds for the GE Hitachi unit, with 2020 costs projected at $2,883/kW and the 2023 costs at as high as $12,347/kW.

A recent academic study by Asuega, Limb, and Quinn[23] shows that different studies provide a range of OCCs between $3,782 and $4,978/kW for light water SMRs. Their modeling analysis estimates the OCC to equal $4,355 /kW and an LCOE of $90 /MWh for a light-water SMR. The overall and per KW costs of TVA's proposed SMR have not been disclosed.

Newly implemented FOAK technologies commonly come at a high cost, with costs falling through subsequent deployments. This means that the economic impact of initial units will be larger than the impacts from subsequent units. The same high costs for initial units represent a significant barrier to entry for new technologies like SMRs. Because electricity prices must remain competitive to avoid adverse impacts on economic development, this is a major challenge for TVA and other utilities considering SMR adoption.

Economic Impact Modeling: Background

Economic impact analysis is the standard tool used to estimate the consequences of changes in economic activity, from the location of a new manufacturing firm to the closure of a coal-fired power plant. The same tools are employed here to measure the effects of SMR construction and operations spending on the Tennessee economy. The following discussion starts by providing background on the methodology underlying the estimation and then briefly reviews the limited research on the economic impacts of SMRs. The next section presents the results and findings.

Estimation methods. The most important feature of economic impact analysis is that it is driven by expenditures. Economic impacts originate through *direct* spending, in this instance by TVA and its partners and prime contractors. This includes payroll disbursements as well as the acquisition of supplies, equipment, construction materials, aggregate, fuel, machinery, wiring, reactor materials, and so on that are tied to facility construction and operations.

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[22] David Schlissel and Dennis Wamsted, "Small Modular Reactors, Still Too Expensive, Too Slow and Too Risky." Institute for Energy Economics and Financial Analysis. May 2024. https://ieefa.org/sites/default/files/2024-05/SMRs Still Too Expensive Too Slow Too Risky_May 2024.pdf

[23] A. Asuega, B.J. Limb and J.C. Quinn, 2023. Techno-economic analysis of advanced small modular nuclear reactors. *Applied Energy*, *334*, 120669.

Since the focus is Tennessee, it is essential that the direct spending used in the impact modeling be confined to in-state expenditures. The reason is that spending incurred outside the state generally has an inconsequential impact, if any impact at all, on the state economy. For example, precision-machined pipe fittings acquired from an out-state-vendor would have an impact on the state of origin, not Tennessee. Installation of these same fittings could impact the state and would, in principle, be captured through construction and installation spending, which is included in the analysis. Nuclear fuel is an example of a costly input that will be sourced from outside the state. Because a significant share of inputs for SMR construction would come from out of state, there are potentially large first-round direct spending leakages that create economic impacts elsewhere. This is the case for virtually all businesses since no regional economy has the capacity to produce everything it needs. While many tangible inputs to construction will come from outside the state, considerable payroll and nonpayroll spending will be incurred in Tennessee, yielding substantial economic benefits.

Direct spending on the project is the first of many rounds of economic impact for both construction and operations. Nonpayroll expenditures on goods and services initiate *indirect spending* that works through the business supply chain, from sophisticated components to mundane janitorial and landscaping services. This boosts in-state business activity, creating additional nonpayroll spending, employment, and worker payrolls in firms across the state.

Payroll tied to direct spending—construction workers and TVA oversight personnel—will largely be spent in the state, initiating *multiplier effects*. Similarly, as workers in the supply chain receive their income, most will be spent in Tennessee, creating additional multiplier effects. The ripples span business sectors, including retail trade, finance, insurance, services and so on. Multiplier effects influence virtually every sector of the state economy. For example, a TVA employee may purchase an automobile made in Tennessee, which enhances production activity in the state's automotive sector. Workers in the automotive sector expend their income on a range of goods and services, further enhancing employment and payroll across the state. These workers, in turn, expend income in Tennessee, yielding additional income, employment, and state production of goods and services. The *multiplier* measures these ripple effects. Together, the direct, indirect, and multiplier effects capture the overall economic impacts on the state.

While in-state expenditures are the impact driver, measures of economic benefit used here are wage and salary income that accrues to Tennesseans, jobs held in the state, and state gross state product. These metrics are commonly used in economic impact analysis since they reflect benefits that accrue to the state and its residents.

Each economic impact benefit measure—income, employment, and GDP—has a multiplier associated with it. The income multiplier, for example, captures the number of times a dollar turns over in the economy. The income multiplier accounts for the leakage of purchasing power that arises from out-of-state spending and savings at each round of the process. The employment multiplier indicates how many jobs would be created in total from one direct job. For example, an employment multiplier of 2.0 means that one additional job is created for each direct job tied to the project. Multipliers tend to be larger for larger regional economies because there are fewer leakages at each round of the spending process. In practice, this means that state-level multiplier impacts will tend to be larger than local-level multiplier impacts.

The analysis here uses RIMS II multipliers for the Tennessee economy that are acquired from the U.S. Bureau of Economic Analysis.[24] These data are built on actual industry data that account for business-to-business transactions and other economic linkages.

Other SMR impact studies. A small number of studies have explored the potential economic impacts from SMR construction and deployment, though none are specific to a potential TVA project in Tennessee. One is an analysis that considered the impacts of $1 billion in hypothetical construction spending on an SMR.[25] This study did not examine a specific input spending profile on goods, services, and payroll but simply assumed a $1 billion construction cost. Direct employment associated with construction is estimated to be 9,647, with a total employment of 16,164, including indirect and multiplier effects. The $1 billion in direct spending on the facility would create $2.1 billion in total output. Direct employment of 1,128 for operations would create 4,200 total jobs, with annual direct spending of $1.0 billion supporting $1.8 billion in total output. A similar study was released in 2010 that considered the economic impact of a "prototypical 100 MW SMR" that would cost $500 million to construct.[26] The estimates indicate a total construction impact of 7,000 jobs and $404 million in earnings for workers. Operational impacts were estimated to yield 375 jobs with $27 million in earnings. The multipliers for this second study generally range between 2.5 and 2.9.

A summary of a third report notes that a 600 MWe SMR could create $500M in output each year with an employment multiplier ranging from 1.7 for a local community and 2.4 for the host state.[27] A fourth study undertaken by the Conference Board of Canada for Ontario Power Generation considered the construction and operation of an SMR in Canada.[28] The estimates are based on lifetime returns and indicated an output (GDP) contribution of C$15.3 billion. Employment impacts would total an average of 2,000 jobs per year. Few details are provided for either of these studies.

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[24] For an introduction and additional resources see https://www.bea.gov/news/blog/2020-08-03/bea-updates-regional-economic-tool. Alternative models include REMI (https://www.remi.com) and IMPLAN (https://implan.com/) The latter two propriety economic impacts models use the same core data to develop their modeling framework and multipliers.

[25] E4 Carolinas, "The Economic Impact of the Nuclear Industry in the Southeast United States: A Regional and State-Level Analysis," February 2024.

[26] The Energy Policy Institute, "Economic and Employment Impacts of Small Modular Reactors," June 2010. https://www.nrc.gov/docs/ML1802/ML18023A166.pdf

[27] SMR Start, "The Economics of Small Modular Reactors." March 2021. http://smrstart.org/wp-content/uploads/2021/03/SMR-Start-Economic-Analysis-2021-APPROVED-2021-03-22.pdf

[28] Conference Board of Canada, "Ontario Powe Generation: Economic Impact Analysis of Small Modular Reactors (SMRs)," 2023. https://www.opg.com/releases/opgs-smrs-will-generate-jobs-and-lasting-economic-benefits-for-ontario/

The most detailed study available evaluated the impacts of potential SMR construction on a 16-county region in eastern Idaho.[29] The proposed NuScale SMR that was evaluated would include 12 modules with 60 megawatts of capacity per unit. Total project costs were estimated to be $2.5 billion, with $1.4 billion of direct spending anticipated in eastern Idaho. The total employment impact across the four-year construction period was estimated to be 13,422 (or an average of 3,356 jobs per year), with the creation of $644.2 million in labor income. While the SMR project is similar to the TVA proposal, the regional scope of the analysis is rather different, which has implications for the magnitude of estimated impacts. Most significant is that the population of the 16-county region (389,841) is just 5.8 percent of the Tennessee population (6.8 million) in 2018. A much smaller population means far less economic diversity and far greater leakages of expenditures at each round of spending, reducing both supply chain and multiplier impacts. Worker salaries on the project were also much lower than the salaries for the TVA project, which means lower *levels* of income injected into the region to support the multiplier.

Economic Impact Modeling: Estimates

This section provides estimates of the economic impact of SMR construction and operations based on data provided by TVA. The discussion starts with an overview of the scope of the project and input data and then turns to construction impacts, operational impacts, and overall impacts.

Project overview and input data. TVA has been working for several years to lay the foundation for the potential construction of one or more SMRs at its Clinch River site. TVA is currently engaged with GE-Hitachi, which owns a proposed SMR technology, and is in the process of seeking approvals from the Nuclear Regulatory Commission; pre-site approval has been granted. At this time, neither a construction permit nor an operating permit has been issued. Importantly, TVA has not made a firm commitment to move forward with the project. Based on direct communication with TVA: "Any decisions will be subject to support, risk sharing, required internal and external approvals, and completion of all necessary environmental and permitting reviews."

Many of the costs incurred to date are one-time planning and regulatory costs that total well over $100 million. These are not included in the impact analysis presented here. The expenditure data that have been provided for both construction and operations are confidential estimates and presented at a relatively high level of aggregation. This level of detail is nonetheless more than adequate to enable economic impact analysis.

Construction activity could begin as soon as the necessary permits have been granted. Construction would continue into 2032, at which time operations and power generation could begin. The analysis of construction includes startup and commissioning activity by TVA personnel.

[29] Idaho Policy Institute and McLure Center for Public Policy Research, University of Idaho, "Economic Impact Report: construction and Operation of a Small Modular Reactor Electric Power Generation Facility at the Idaho National Laboratory Site, Butte County, Idaho," January 29, 2019. https://www.rediconnects.org/wp-content/uploads/2019/02/SMR-Economic-Impact-Report-FINAL.pdf

Construction overview. TVA has shared some of the key assumptions underlying the data that have been provided on the construction phase. These are important to understanding what is and what is not included in the impact assessment:

- Data provided are specifically targeted at project construction-related work performed inside Tennessee;
- First of a Kind (FOAK) engineering, original equipment manufacturer (OEM) engineering to adjust the standard design to site, and any other design engineering-specific costs are not included;
- Engineering work and planning field engineering, including change engineering, is included;
- Operations and operations support development, staffing and training are included in the estimate, including staffing numbers;
- Commodities and materials cash flow include only cash flows for items that can be potentially purchased in the state of Tennessee;
- OEM equipment cash flows, long lead equipment, and specialty items are not included in the Commodities and Materials cash flow;
- Indirect craft (riggers, operators, etc.) are included as a separate line item in the Labor section;
- Contractor equipment purchases are not assumed to be acquired in Tennessee and are not in the construction estimates;
- Construction planning by project management, etc., does not include EPC (Engineering, Procurement and Construction) contractor home office support.

Because the SMR technology being evaluated for potential deployment is owned by GE-Hitachi, they will have considerable control over input sourcing for the project.

As noted above, the expenditures expected to be incurred in Tennessee are isolated from overall spending on the project. There are several assumptions embedded in the data that may lead to underestimation of impacts, including the omission of some FOAK costs, potential OEM acquisitions in Tennessee that are not accounted for, and construction equipment purchases that might take place in Tennessee. Specific items that will be purchased out of state include: Reactor Pressure Vessel (RPV), Reactor Internals, Reactor Isolation Valves, Main Steam Isolation Valves, and Turbine/Electric Generator.

The current workplan expenditure estimates have construction labor force, construction management, construction engineering, and permanent staff budgeted for the current year through 2032; construction material acquisition in Tennessee is assumed to begin in 2026 and cease in 2031.

All construction labor will be sourced from Tennessee. This is important since in-state labor will be used to assemble/install an extensive array of inputs purchased from both inside and outside the state. Startup and commissioning will be staffed by permanent TVA employees, most or all of whom reside in Tennessee.

Total project spending in Tennessee will be $1.4 billion. These data have been adjusted so that they are net of state and federal taxes, as well as employee benefits like pensions that are generally not included in impact modeling.[30] Across all years of the project, adjusted direct labor costs total $661.0 million, and commodity and materials costs total $379.2 million, for a total of $1,040.2 million in expenditures incurred in Tennessee. Estimates of *total* SMR construction costs are unknown at this time. Assuming a hypothetical cost in the range of $3 to $4 billion would imply that significantly less than one-half of the costs are being sourced in the state. Construction-person years are projected to total 4,867 or about 541 workers per year on average. Peak employment years are late in the current decade.

Workers engaged on the project will generally earn high wages and salaries, reflecting the complexity of the construction, management, engineering, and oversight that is necessary for SMR construction and operation. The average annual salary for the construction phase is $135,804, reflecting high salaries for management professionals and the construction labor force. These high salaries have important implications for the magnitude of estimated economic impacts as they will drive large volumes of spending through the multiplier process, yielding significant numbers of jobs and robust growth in state output.

Construction impact estimates. The estimated impacts of construction and startup on employment, income, and output are presented in Tables 1-3. All monetary data presented here and elsewhere below are in nominal terms unless otherwise indicated.

Direct employment impacts start in 2024 with a total of 9 person-year direct jobs, jumping to 919 jobs in 2029, then falling to 276 jobs in 2032, at which time TVA's startup and commission workforce will be larger than construction employment. Over the course of the construction phase, 4,867 person-year jobs are supported.

Construction-related nonpayroll spending is zero in 2024, 2025, and 2032, so there are no impacts on the supply chain in these years. However, multiplier income is generated from payroll spending in these same years. (Note from the discussion above that only nonpayroll spending affects the supply chain, while all spending has a multiplier impact.) *Indirect Plus Multiplier* employment estimates start at 18 jobs in 2024, rising to 292 jobs in 2025, and then increase significantly as construction activity (including nonpayroll spending) accelerates. Peak indirect and multiplier employment comes in 2029 with 2,350 jobs. Total indirect and multiplier employment supported by construction across all years is 11,573 person-years.

The total employment impact reported in the last column of **Table 1** accounts for direct jobs as well as indirect and multiplier jobs. Beginning at 27 jobs in 2024, the total employment impact reaches a peak of 3,269 jobs in 2029. Total person-year employment is 16,440 for an average of 1,827 jobs per year

Note that the final row of Table 1 implies that the employment multiplier is 3.4 (16,440/4,867), indicating that each job created in construction produces an additional 2.4 jobs through supply chains and the

[30] Pensions are an important deferred benefit program for workers but spending impacts do not occur until retirement. Health insurance benefits are generally omitted from economic impact modeling because of the difficulty of making linkages to in-state spending.

multiplier process. This large employment multiplier impact is attributable to the relatively high salaries of construction, management, and startup workers noted above, which means a large amount of new purchasing power is injected into the state economy. The average salary for this labor force ($135,804) is more than twice the statewide average wage of $67,800 for all Tennessee workers in 2024.[31] This volume of construction-related payroll income fuels support for large numbers of jobs through the multiplier effect. In other words, a job paying twice the state average can support many more jobs through the multiplier process than one paying the statewide average.

Table 1: Employment Impacts from Construction

Employment			
Year	Direct	Indirect Plus Multiplier	Total
2024	9	18	27
2025	209	292	501
2026	707	1,511	2,218
2027	595	1,924	2,519
2028	695	2,108	2,803
2029	919	2,350	3,269
2030	869	2,116	2,985
2031	589	941	1,530
2032	276	313	588
Total	**4,867**	**11,573**	**16,440**

Income impacts for construction are reported in **Table 2**. In 2024, direct income is just $1.9 million, rising to a peak of $119.7 million in 2030. Total direct income across all years is $661.0 million, or $73.4 million per year.

Indirect Plus Multiplier income rises sharply following 2025 to $91.3 million in 2026, largely reflecting construction nonpayroll spending. Total indirect and multiplier income across all years amounts to $702.3 million or $78.0 million per year. The total income impact (including direct, indirect, and multiplier effects) starts at just $3.0 million in 2024, climbs rapidly to $181.9 million in 2026, peaks at $256.2 million in 2029

[31] Appendix A, Table 1, An Economic Report to the Governor of Tennessee, 2024, Boyd Center for Business and Economic Research, the University of Tennessee, https://haslam.utk.edu/publication/economic-report-to-the-governor-2024/

and then falls to $65.0 million in the final year of construction. Total income estimated to accrue to workers in Tennessee is $1.4 billion or $151.5 million per year.

The implied income multiplier is 2.1, using the total income figure across all years ($1.4 billion) divided by total direct income ($661.0 million). In other words, each dollar of income expended on the projected yields just over another dollar of income for a worker in Tennessee.

Table 2: Income Impacts from Construction

Income			
Year	Direct	Indirect Plus Multiplier	Total
2024	$1,909,593	$1,124,136	$3,033,729
2025	$26,716,566	$17,753,147	$44,469,714
2026	$90,602,149	$91,284,170	$181,886,319
2027	$79,333,181	$116,022,267	$195,355,448
2028	$92,516,519	$127,166,666	$219,683,184
2029	$114,315,752	$141,885,684	$256,201,436
2030	$119,662,482	$128,659,418	$248,321,901
2031	$91,184,460	$58,139,001	$149,323,461
2032	$44,710,174	$20,246,731	$64,956,906
Total	**$660,950,876**	**$702,281,221**	**$1,363,232,097**

Table 3 provides impact estimates of SMR construction on the state's output, i.e., state GDP. Because there is no nonpayroll spending incurred in Tennessee in the first two years and in the last year of construction, there are no *direct* impacts on output in these years. (It is likely that nonpayroll acquisitions will take place outside Tennessee in all years of the project.) Other years show the direct output (i.e., nonpayroll spending) associated with materials and commodities acquisition in Tennessee. The total direct output from nonpayroll acquisitions is $379.2 million or $42.1 million per year of the project. The indirect/multiplier impact on output rises sharply in 2026 when nonpayroll expenditures come into play and income from payrolls grows (see Table 2). Total output from the supply chain and multiplier is $1.2 billion across all nine years or $133.1 million a year. The total impact accounting for direct, indirect, and multiplier effects is nearly $1.6 billion or $175.2 million per year.

The ratio of total output ($1.6 billion) to direct output ($379.2 million) implies an output multiplier of 4.2. This relatively large multiplier reflects the absence of any direct spending impact for three years of the project as well as significant amounts of income supporting multiplier impacts on output.

Table 3: Output Impacts from Construction

Output			
Year	Direct	Indirect Plus Multiplier	Total
2024	$0	$2,894,752	$2,894,752
2025	$0	$40,499,643	$40,499,643
2026	$39,746,126	$157,848,824	$197,594,950
2027	$84,260,107	$163,730,958	$247,991,065
2028	$87,289,904	$185,278,652	$272,568,556
2029	$87,289,904	$218,324,110	$305,614,014
2030	$73,665,547	$219,400,413	$293,065,960
2031	$6,965,312	$141,819,927	$148,785,239
2032	$0	$67,776,153	$67,776,153
Total	**$379,216,900**	**$1,197,573,431**	**$1,576,790,332**

Economic impacts for a representative year of operations. The proposed SMR would have a life span of 40 – 60 years. During this time period, there will be ongoing operational spending as well as spending tied to maintenance, refueling, and upgrades. Nonpayroll spending data from TVA include broad categories—e.g., general and administrative, fuel and control blades, dry casks, and waste treatment. Some TVA costs are omitted here, specifically those for outages and a decommissioning fund. The reason is that these categories do not necessarily represent actual expenditures injected into the economy that support typical year activities—the expenditure of these funds would create economic impacts that are not accounted for here. Capital expenditures are estimated by TVA to be $2.1 million a year for costs incurred in Tennessee. The facility would be staffed by 205 workers who earn an average salary of $121,057 per year.

The *representative year* impacts are summarized in **Table 4**. Direct nonpayroll spending amounts to an output contribution of $35.5 million. Indirect and multiplier impacts add $63.0 million to state output. Together, the output effect for a representative year of facility operations totals $98.5 million. The output multiplier is estimated to be 2.8.

Direct payroll income amounts to $24.8 million, and indirect and multiplier income amounts to $32.0 million. Total income for Tennessee workers is $56.9 million. The income multiplier tied to operations is 2.3. Direct employment is 205, and indirect/multiplier employment across the state is 512. Together, the ongoing employment impact is 717 jobs per year. The employment multiplier is 3.5, once again reflecting the substantial income generated from payroll spending that supports greater employment creation across all sectors of the state economy.

Table 4: Representative Operational Year Impacts

	Output	Income	Employment
Direct	$35,496,129	$24,816,704	205
Indirect Plus Multiplier	$62,974,526	$32,040,650	512
Total	$98,470,655	$56,857,353	717

Implications of increased state sourcing of inputs. The multipliers noted above can be used to reveal the broad implications of additional direct output purchases, employment, and income for both construction and operations. For example, an additional job tied to construction would lead to the creation of 2.4 jobs elsewhere in the state economy based on the figures presented above. An important caveat is that these multipliers are *aggregate*, capturing the mix of spending, salaries, and employment embedded in the source data for the project. Even the simple example here of one additional *construction worker* is problematic since the actual workforce will include construction labor, construction management, and permanent TVA staff engaged in startup. If the mix of spending and/or direct salaries changes, the multiplier effects estimated here may not be precise.

Growing the in-state supply chain could have a material impact on the benefits of both construction and operations. For example, for the representative year analysis, a 50 percent increase in spending on fuels and control blades sourced in Tennessee would increase the overall operational income impact by 4.8 percent and support an additional 40 full-time jobs for Tennesseans. While it is not known whether this is feasible, it does illustrate the potential economic benefits of drawing a specific element of the supply chain closer to the facility. Turning to a second example, if radioactive waste treatment expenditures increase by 30 percent, the total operational income impact would increase by 1.2 percent and support an additional 10 jobs. These hypothetical scenarios demonstrate how changes in estimated operational expenditures or in the states' supporting supply chain affect the economic impacts for Tennessee's economy.

Potential state and local tax impacts. Tax impacts from construction and operations can be estimated using the output estimates from the economic impact model coupled with data on state and local tax collections. The focus here is *taxes* because other revenue sources, like intergovernmental aid from the federal government, are difficult to link to changes in in-state economic activity. Taxes, on the other hand, are generally tied directly to economic activity, particularly the sales tax which is the state's most important revenue source and the second most important tax source for local governments.

TVA pays a gross receipts tax (i.e., PILOT or payment in lieu of tax) to the State of Tennessee that is based on power sales. Revenues accruing to Tennessee are significant, amounting to $410 million in fiscal year

2022/23.[32] Estimated PILOT revenue is not separately accounted for but is implicitly included in the estimates presented here since they account for gross receipts taxes generally.

State and local revenue estimates presented here account for the sales, corporate income, gross receipts, and local property taxes, as well as special excise taxes on cigarettes, alcoholic beverages, and other transactions.[33] Based on the estimates of output presented above, construction would produce $14.7 million a year in state and local taxes for cumulative collections of $132.5 million across all nine years of the project. Operations would yield total state and local taxes of $8.3 million per year.

Special Considerations

There are many nuances that underlay economic impact modeling. Moreover, many facets of the SMR project are unique, including FOAK costs. The following sections highlight some of the more salient issues that should be considered when evaluating the estimates presented in this report.

Federal support and national security. The federal government has keen interest in growing the nation's nuclear sector to support clean energy, energy independence and national security, as well as RDD&D. The recently passed Advance Act[34] shows this commitment:

- Strengthens U.S. energy resiliency by investing in domestic nuclear energy infrastructure, research, and workforce, building upon international collaborations and relationships to advance nuclear technologies, and ensuring national security through energy independence.
- TITLE II Section 102 of the act- $900M in for nuclear prizes- Up to $800M to support Gen III+ Small Modular Reactor (SMR) projects & up to $100M for projects assisting in SMR supporting design, licensing, supplier development, and site preparation of a grid-scale Gen III+ reactor design.
- Improving Nuclear Regulatory Commission efficiency, strengthening of the NRC workforce, and streamlining of processes like NEPA reviews and licensure demonstrate commitment to address key challenges in developing and deploying SMRs and new nuclear technologies, including fusion.

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[32] Tennessee Advisory Commission on Intergovernmental Relations, "Tennessee Valley Authority Payments in Lieu of Taxes, https://www.tn.gov/tacir/tva-pilots.html For details on how these funds are allocated, see TVA In Lieu of Tax Payments, https://www.ctas.tennessee.edu/eli/tva-lieu-tax-payments#:~:text=TVA%20in%20lieu%20of%20tax%20payments%20are%20payments%20made%20by,is%20determined%20by%20federal%20law.

[33] Data are drawn from the State and Local Finance Data calculator provided by the Urban Institute. The calculator allows users to choose from a variety of tax measures, ranging from specific taxes to highly aggregated measures of revenue. The calculator also provides *tax burden* measures, including taxes per capita and taxes as a share of personal income. The tax measure used here is (R05) Total Taxes. See https://state-local-finance-data.taxpolicycenter.org/pages.cfm

[34] The White House, "Statement from National Climate Advisor Ali Zaidi on Signing of the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act into Law," July 9, 2024. https://www.whitehouse.gov/briefing-room/statements-releases/2024/07/09/statement-from-national-climate-advisor-ali-zaidi-on-the-signing-of-the-accelerating-deployment-of-versatile-advanced-nuclear-for-clean-energy-advance-act-into-law/

This and other initiative mean federal financial support as well as support in moving good investments forward.

Supply chain, production costs and technology. The RIMS II economic impact multipliers used here for income, employment, and state GDP account for the existing inter-industry structure and supply chain in Tennessee; actual data on business transactions underlays the development and estimation of these (and other) regional multipliers by the U.S. Bureau of Economic Analysis. The economic linkages are necessarily retrospective, i.e., based on what has happened in the past as reflected in historical data on business-to-business transactions and other economic activity. Business supply chains evolve over time so one would expect a growing supply chain in Tennessee if SMR construction takes place, especially if multiple units were to be produced and deployed. Proximity alone would attract firms by reducing transportation costs and improving communications and networking both along the supply chain and with TVA and its contractors.

The multipliers implicitly assume that greater spending can occur with no changes in the unit costs of production. In the short run, costs may rise because of capacity constraints. On the other hand, over time, an increased scale of production can lead to lower per unit costs for many inputs and components. The reason is that increased scale allows the fixed costs of capital (that embodies production technology) to be spread across more and more units of production. These lower costs might occur if multiple SMRs were to be built in Tennessee. The implication is that the economic impact of the first SMR would likely be larger than the impacts of subsequent SMRs. Lower costs would, in practice, manifest themselves first in the costs TVA would incur for additional units. These lower costs would then be reflected in a smaller economic impact.[35]

The technology underlying goods and services production in Tennessee is also assumed to be static when economic impacts are measured. This makes sense in the short run because most businesses have fixed equipment *and* processes to guide production activity. Improvements in technology and production processes can also lead to lower unit costs, regardless of scale. Lower costs arising from technology would also translate into a lower economic impact on the state. At the same time, it could lead to growth in other sectors directly or indirectly tied to the nuclear sector, benefits that are no accounted for here.

A smaller economic impact from lower input costs does not diminish the importance of SMRs as a source of clean, safe baseload electric power for Tennessee. Nor does it diminish the potential economic development benefits that could arise from growing the state's nuclear sector. Alternative power generation from natural gas, for example, would not likely lead to robust technology, R&D, and workforce development spillovers like those discussed below from SMR development.

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[35] Increased in-state *sourcing* would lead to higher impacts on Tennessee, potentially offsetting the effects from lower per unit input costs.

FOAK costs and the learning curve. The lack of active component production for many inputs means that the first SMRs to be built will confront potentially significant FOAK costs. Prominently, this would include reactor vessels and their essential component parts. On the other hand, turbines, cooling towers, and switchyard equipment are examples of inputs and costs that are standard for power generation facilities, with a well-established and potentially regionally anchored supply chain for component manufacture. Some off-the-shelf components are already approved for use in sensitive applications like power generation and could conceivably be acquired from established vendors. There are numerous other costs that are not new. Many facets of site development are standard costs, including land clearing and basic site preparation. Burying the SMR reactor in the ground would include some costs that would rely on well-known construction procedures and the use of traditional aggregate fill; new costs would be incurred because of the uniqueness of the SMR and the need to insure the reactor against risks like seismic events. While no good estimate is available, a commonly noted figure is that FOAK costs represent about 50 percent of the project's cost.

Elements of out-of-pocket FOAK costs are included in the purchase of unique inputs (including the examples noted above), regulatory costs, testing and readiness activities, and possible project cost escalation. TVA has incurred about $20 million in Nuclear Regulatory Commission fees to date related to the *Early Site Permit* and the *Construction Permit Application*; total projected costs for TVA to obtain the *Early Site Permit* and develop a *Construction Permit Application,* including the Nuclear Regulatory Commission fees, is about $100 million. Additional reactors would be less costly once the regulatory precedent has been established. The cost of activating the reactor and testing it for safety and performance would be unique, even though all generation facilities need testing prior to deployment. Procurement cost estimates are always subject to revision over time. However, this can be especially problematic for the construction of new capital projects that have no market precedent.

SMR construction, maintenance, and operation would require a high-wage and highly skilled workforce, including design experts, project engineers, construction labor, and operational specialists. While reliance would be placed on many traditional trades and occupations (welders, electricians), these workers may require unique training and skills. In general, labor costs will be high due to the relative scarcity of skilled workers and professionals and the need for specialized training.

Several prominent FOAK SMR *risks* include the necessary long-term financial payback period, design/performance risk, and high cost per KW hour, which makes generation less competitive. Related risks include the potential for the emergence of lower-cost alternatives to the GE-Hitachi model and a technology disruption like a breakthrough in battery technology that would allow storage of intermittent wind and solar power. The ultimate risk is that the SMR becomes a stranded asset that requires cost recovery from ratepayers (and possibly the public sector), while GE-Hitachi loses the return on its investment. TVA and GE-Hitachi share these risks to varying degrees.

GE-Hitachi asserts that their BWRX300 reactor has a FOAK cost of $1 billion or less and a $2,250/kW for the n^{th} unit,[36] with the LCOE between $35 to $50/MWh.[37] NuScale states that its SMR has a LCOE of $68/$100 for a FOAK unit and $61/$86 for the n^{th} of a kind (NOAK) reactor, for municipally owned or investor-owned utilities, respectively.[38] The lower costs for municipally owned facilities are due to risk sharing with the public sector. While the estimates are now somewhat dated, the NuScale figures imply cost savings of roughly 10 – 14 percent for n^{th} unit production compared to first unit production.

A 2023 report from the EFI Foundation[39] offers a policy framework on how to tackle risk and uncertainty regarding FOAK costs. This is just an example, but it is illustrative. The report notes that the first-mover disadvantages can be managed through three steps:

1. *Demand Pooling* – a commitment by multiple actors to construct and operate the same SMR design, similar to the creation of an "orderbook" for a specific airplane deployed by numerous airlines.

2. *Knowledge Sharing* – costs decrease, and estimates become more certain through successive builds of SMRs within an orderbook. The building of the first SMR followed by iterative builds allows for knowledge sharing across "engineering, procurement, and construction (EPCs) firms, the project sponsors, the financial community, third party design and engineering entities, trade and training facilities, academia, and regulatory and policymaking entities."

3. *Risk Sharing* – is enabled through tiers, (i) within the project group through the implementation of an integrated project delivery agreement (IPD) amongst the key stakeholders that allows for the sharing of information and limiting costs; and (ii) outside the project group, "overrun risk" should be borne partially by an outside entity that has sufficient capacity to absorb costs, such as a government entity.

One lure of constructing multiple SMRs is the potential for lower costs of input acquisition and the realization of a learning curve that helps make SMRs a more competitive power source.[40] The scope of the savings is unclear and would depend on the number of units to be constructed. In terms of the language immediately above, no one knows exactly what savings would accrue from the *n^{th} unit*. Savings would likely be muted for a very small number of SMRs. The learning curve would arise from experience on the

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[36] GE Hitachi Nuclear Energy, "Deep decarbonization with nuclear," March 2019. https://thinkatom.net/wp-content/uploads/2020/03/christer-dahlgren-ge-hitachi-bwrx-300-deep-decarbonizing-with-nuclear-1.pdf

[37] These figures do not reflect more recent, higher cost estimates noted above. See Advanced Reactors Information Systems, "Status Report – BWRX-300 (GE Hitachi and Hitachi GE Nuclear Energy)," International Atomic Energy Agency, September 30, 2019. https://aris.iaea.org/PDF/BWRX-300_2020.pdf

[38] NuScale Power, "Nuscale Levelized Cost of Energy," 2022. https://www.nuscalepower.com/-/media/nuscale/pdf/fact-sheets/lcoe-fact-sheet.pdf

[39] Ernest J. Moniz, "A Cost Stabilization Facility for Kickstarting the Commercialization of Small Modular Reactors," EFI Foundation, October 2023. https://efifoundation.org/wp-content/uploads/sites/3/2023/10/20231011-CSF-FINAL-1.pdf

[40] Lower costs can arise from economies of scale as well as improved processes.

part of an owner and its workforce as well as suppliers that improves productivity. For example, the construction of one new home by a work crew would likely take more time and, therefore, cost more than the per-house construction of many homes with the same blueprint. The same principle would apply to SMR construction, especially if the design was common. Welding the first reactor vessel would take more hours of labor than welding the 20th reactor. Management of a complex engineering project can also be expected to yield cost savings through the learning curve. TVA is addressing the procurement and acquisition question behind the scenes and knows something about how costs may fall with the production of multiple units.

Potentially high FOAK out-of-pocket and risk costs represent significant barriers to entry for SMRs, like the barriers that generally exist for the introduction of other new products and technologies. While they have a bearing on estimated economic impacts, the real issues are cost and risk sharing that may be required to allow construction and deployment to move forward.

Clusters and agglomeration economies. Clusters and agglomerations are often characterized to include businesses and sectors that formally trade with one another—think *supply chain*. Location can be important, if not essential, to supply chain cluster development by making inputs less costly by virtue of proximity. With proximity comes a host of benefits, including lower transportation costs and easier, often direct communication with business partners. The key is that the proximate or co-location of businesses imparts lower costs.

Importantly, the role of clusters can go beyond the supply chain to capture spillover effects that are not tied directly to business-to-business transactions. These spillovers entail lower business costs and lead to what economists refer to as *agglomeration economies*. As economic development guru Michael Porter notes, it "allows each member to benefit *as if* it had greater scale or *as if* it had joined with others without sacrificing its flexibility."[41] In other words, a business may find a region to be a more attractive location by virtue of lower costs, even if it has no business dealings with other firms in the same regional economy.

For example, businesses that do not trade with one another may rely on similarly skilled workers, creating a broader labor pool within a region. This enhanced labor pool may lower employer and employee search costs, offering businesses improved productivity and workers higher salaries through better matching and skills alignment. For the state's nuclear sector, this could include jobs ranging from nuclear engineers to security guards and communications specialists. Companies may find that training resources are lower cost when other companies require the same or similar training. Common bidding systems and contracting experience with federal agencies and prime contractors can be shared while also creating a pool of uniquely skilled workers. Information exchange and the synergies of research are enhanced by the nearby location of workers in other firms as well as educational institutions like the University of Tennessee, where scholars are working on similar projects. It is generally agreed that knowledge-based industries have

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[41] Michael E. Porter, "Clusters and the New Economics of Competition," *Harvard Business Review* November-December 1998. https://hbr.org/1998/11/clusters-and-the-new-economics-of-competition Emphasis in the original.

the potential to benefit the most from agglomeration.[42] Knowledge-based industries, in turn, enhance the economy and its performance, including the cultivation of high-skill and high-wage jobs.

Direct cluster linkages *between* firms as well as spillovers *across* firms are both of particular interest for the nuclear sector anchored in the Oak Ridge region that spills across Tennessee and other states. Depending on the firm, it may include lower transportation costs, lower search costs for employers and workers, information sharing, and knowledge spillovers, as noted above. Information sharing may take place through informal networks and formal business associations (e.g., ETEC); these same communications may identify supply chain gaps more quickly than standard market forces. For business-to-business transactions, proximity translates to lower transportation costs, whether for the movement of goods or simply for face-to-face meetings. Peer effects and the pursuit of largely common goals—nuclear deployment—can enhance morale and productivity. Anyone who has done business in the Oak Ridge community is aware of this unique and ubiquitous driving spirit.

An agglomeration cluster already exists in the East Tennessee region that is especially robust and generally known to many professionals and others in the community and has been documented by ETEC. One way to summarize the group of industry sectors is with the North American Industrial Classification System taxonomy.[43] There are multiple businesses with nuclear-related activities that can be placed into these NAICS categories:

- 21 Mining, Quarrying, and Oil and Gas Extraction
    - Beneficiation of mineral ores (uranium, radium, vanadium)
- 23 Construction
    - Power and communication lines and related structures
- 32-33 Selected Manufacturing Sectors
    - Chemical manufacturing, pharmaceutical and medicine manufacturing, metal products and metal working machinery, control instruments, battery manufacturing, uranium enrichment, nuclear medicine
- 51 Information Computer infrastructure providers, data processing, web hosting, related services
- 54 Professional, Scientific, and Technical Services
    - Geographical surveying and mapping, testing laboratories and services, computer systems design, research and development
- 56 Administrative and Support and Waste Management and Remediation Services
    - Security guards; hazardous waste collection, treatment, and disposal; remediation services

[42] Kathleen Bolter and Jim Robey, "Agglomeration Economies: A Literature Review," W.E. Upjohn Institute for Employment Research, 2020. https://research.upjohn.org/cgi/viewcontent.cgi?article=1256&context=reports s
[43] The complete NAICS accounting system is supported by the U.S. Census Bureau, https://www.census.gov/naics/

Importantly, inducing cluster growth by targeting specific components of the cluster can yield spillover benefits and enhance agglomeration economies. This means that attracting more SMR-related activity will have significant impacts on growing the overall nuclear cluster and a host of related economic activities in Tennessee.

A recent report takes this broad perspective to its discussion of the regional nuclear cluster in five southeastern states, Georgia, North Carolina, South Carolina, Tennessee, and Virginia. Novel considerations include going behind the scenes to examine businesses in the nuclear supply chain, university-related research and support activities, and federal government entities that have ties to the five-state region's nuclear sector. This information is highly complementary to the discussion here on agglomeration effects, highlighting the rich breadth of related businesses, sectors, and support services, as well as revealing economic benefits.[44]

Workforce and workforce development. Workforce availability and quality will be essential to the SMR project. As with other components of the impact modeling, an underlying assumption is that sufficient labor will be available to meet in-state construction and supply chain needs--this is implicit in the historical data that supports the development and estimation of the multipliers. Sustaining and growing business support sectors will require a well-trained workforce, or business and job opportunities will go elsewhere.

While the workforce is key to SMRs, it is also a key element of industry clusters and agglomeration effects, as indicated above. ETEC has documented 18,596 jobs tied to the nuclear sector.[45] Stakeholders and partners from industry, government, and educational institutions have ongoing discussions of potential gaps in the nuclear workforce through ETEC's Nuclear Working Group.[46] Examples of nuclear sectors considered include the front-end fuel cycle (e.g., processing and preparing uranium for use in nuclear reactors), the back-end fuel cycle (e.g., waste management, storing used fuel, and nuclear commissioning), nuclear security and nonproliferation, nuclear power plants (e.g., nuclear supply chains, reactor component manufacturing, advanced fission reactor technology), medical isotopes and nuclear medicine (e.g., nuclear imaging), and fusion energy (e.g., fusion technology research and design). Note that these industries are generally included in the NAICS categorization presented immediately above.

The types of jobs and educational requirements vary within and across these sectors. A partial list of example occupations includes nuclear technicians, engineers, physicians, biologists, radiochemists, physicists, operators, project managers, and skilled craft workers (e.g., nuclear welders, electricians). While a significant share of jobs require advanced degrees, many others are in various trades and specialty occupations. Many of these occupations will require advanced technical training and on-the-job experience to adequately prepare workers. Note also that many of the jobs and occupations discussed

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[44]Joseph Von Nessen and Lukas Brun, "The Economic Impact of the Nuclear Industry in the Southeast United States, A Regional and State-Level Analysis," E4 Carolinas, February 2024.
[45] This figure from ETEC accounts for only direct employment. A broader measure of employment using a different methodology that accounts for indirect and supply impacts is over 40,000, see footnote 1.
[46] For more information, see: https://www.eteconline.org/nuclear-industry-hub/

here pay very high wages and salaries. Expanding partnerships and nuclear educational programs to fulfill these workforce needs will not only attract new nuclear companies and grow Tennessee's nuclear sector, but also translate into lasting investments in people. This is one of the most important investments that the state can make in its future.

While there is an established nuclear employment base in the region, many workers will be aging out and few new workers are entering the related labor force. The addition of SMR activity at the Clinch River Nuclear site, along with the ongoing needs of the broader nuclear sector, means there will be many new job opportunities, especially in critical supply chains. Fulfilling nuclear workforce needs will mean a renewed commitment to educational and training programs, beginning at the high school level (if not earlier), and include certificates and/or degrees from Tennessee Colleges of Applied Technology, State Community Colleges, and four-year universities in the state. New steps will be required to address the lack of a robust pipeline of workers. Several current partnerships and educational programs exist, and some institutions have recently received funding to support and grow their nuclear programs. For example, the University of Tennessee, Knoxville and Roane State Community College will receive funding from the state's Nuclear Energy Fund.[47] At the University of Tennessee, the funds will go towards establishing a new minor in nuclear engineering, and separately at Roane State Community College, the funds will be used to support a nuclear measurement lab and a new nuclear technology program, which will begin in Fall 2024. Ongoing coordination and evaluation will be needed to ensure success.

Conclusion

SMRs have the potential to help meet the state's energy needs while contributing to the nation's economic and energy security. They would also yield numerous additional economic development benefits, especially for those places that host component production, facility construction, and deployment of generating capacity. Deployment of carbon-free energy will especially be attractive to many energy large consumers, especially new industrial customers that require efficient industrial heat.

For many reasons, Tennessee is a prime site to be a first adopter of SMR technology. The state has a longstanding nuclear presence dating back to the Manhattan Project, and it has embraced nuclear power deployment through TVA generating capacity. Expertise, along with considerable industrial capacity to support SMR construction, is already present in Tennessee. Substantial economic development benefits would come from SMR construction and deployment, including job and income creation and the generation of knowledge spillovers that would not likely arise from the introduction of alternative power-generating capacity.

This report has documented the estimated economic impacts on jobs, income, and state output that might accrue to the state should TVA move forward with the construction and operation of a single GE-Hitachi BXWR300 SMR. The estimated economic impact from the nine-year construction phase (2024-2032)

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[47] See: https://tnecd.com/news/governor-lee-commissioner-mcwhorter-announce-new-funding-for-nuclear-education/

includes a total of 16,440 person-year jobs for an annual average of 1,827 jobs. A representative year of facility operation, beginning in 2032, would include 205 direct jobs held by TVA employees and an additional 512 jobs through the supply chain and the multiplier, producing a total of 717 jobs on an ongoing basis. Overall, the job, income, and output impact of SMR production and deployment would have substantial and long-lasting benefits for Tennessee and its economy. TVA may choose to deploy up to four SMRS, leading to additional economic impacts. If costs and in-state sourcing remain the same as the first unit, each additional unit would have a similar impact on the Tennessee economy.

Appendix D: Tennessee's Nuclear Education Inventory Summary

Tennessee's Nuclear Education Inventory Summary

The development of a targeted technical workforce requires a coordinated education pipeline that spans K through Ph D. For a nuclear workforce, it is important that nuclear knowledge is integrated into the curriculum of each organization: elementary school, middle school, high school, technical academies, community colleges, universities, and industrial apprenticeship programs. Nuclear specific training in Tennessee includes:

K-12:

- Nuclear content is being integrated into K-12 curriculum through elementary readings and activities, middle school STEM days, and a new high school (HS) "Energy" career cluster which is a 4-year HS program including foundational energy courses and a nuclear energy dual credit course with credit transferrable to higher education colleges and universities. The nuclear curriculum will be initially offered by Oak Ridge High School and the Knoxville L&N STEM academy.
- Tennessee high schools also provide technical training programs in industrial maintenance; mechatronics; welding; mechanical, electrical, & plumbing; architecture and engineering design, residential and commercial construction, cybersecurity, and supply chain management. Several of these career cluster programs begin with courses offered in middle school.
- TN invested $500K in technical assistance funding for K-12 nuclear related teacher workshops.

Tennessee College of Applied Technologies (TCAT):

- The 24 Tennessee Colleges of Applied Technology (TCATs) are the state's premier provider of state-of-the-art technical training. The network offers more than 70 occupational programs including Industrial Welding, Industrial Maintenance, Industrial Electricity, Pipefitting and Plumbing Technology, and HVAC.
- Two state Governor's Investment in Vocational Education (GIVE) 3.0 grants are providing TCAT Knoxville $2M for their "Nuclear Science Pathway" and Roane State Community College (RSCC) $450K for *Leveraging Regional Workforce Partnerships to Create Secondary to Postsecondary Pathways for Nuclear Technology*.

Community Colleges:

- Chattanooga State Community College (CSCC) offers several nuclear programs including Nuclear Power Engineering Technology, Radiation Protection, and Quality Assurance/Control Technology.
- RSCC initiated a Nuclear Technology Program in August 2024 with funding from ORNL, a $1.4M Federal Department of Labor Grant and $450K from the TN Nuclear Energy Fund.
- Pellissippi State Community College (PSCC) has a Chemical Radiation Technology program with funding and technical support from ORNL. They also have programs in Welding Technology and Civil and Construction Engineering Technology.

Universities:

- Tennessee Tech University (TTU) launched a new BS program in Nuclear Engineering in Fall 2024 utilizing a $7M in federal funds through congressionally directed community project grants and $1.08M from the TN Nuclear Energy Fund.
- The University of Tennessee's Nuclear Engineering Department hosts the largest PhD program in the country and the 2nd largest undergraduate program. They recently moved into a new $128M building with 28 nuclear laboratories. Their program conducts $18M in research per year. The TN Nuclear Energy Fund has also invested $1M to develop a Nuclear Engineering Minor program to prepare non-nuclear engineers for nuclear related careers.

Project Management certification:

- Several institutions provide education and training leading towards certifications such as the Project Management Professional (PMP). These include PSCC, UT (engineering, business, and certificate programs), TTU, private entities, and several other colleges.

Appendix E: Tennessee Nuclear Energy Workforce Center (T-NEWC) Proposal

Tennessee Nuclear Energy Workforce Center (T-NEWC)

Aligning Tennessee Workforce Investments to Launch a Globally Competitive Nuclear Innovation Hub in Tennessee

Objective:
This document presents a plan to develop an integrated nuclear workforce enterprise in Tennessee. It addresses the need for inter-agency collaboration, resource sharing, and program mapping to bridge gaps in workforce development. The plan aims to establish a coordinated approach, optimizing workforce alignment and positioning Tennessee as a leader in the nuclear industry.

Summary:
The Tennessee Nuclear Energy Advisory Council, in collaboration with Oak Ridge Associated Universities (ORAU) and Global Action Platform (GAP), has initiated a strategic effort to assess and improve the state's nuclear energy workforce development landscape. The end goal is to create a comprehensive, integrated nuclear workforce enterprise that addresses current gaps and prepares for future industry needs. Major gaps identified include the absence of centralized leadership, fragmented efforts across agencies, and geographical disparities in workforce development. Key actions proposed include establishing a coordinating backbone organization and forming a collaborative network of educational institutions. The plan also emphasizes the need for enhanced data analytics, tailored adult education programs, and strengthened engagement with labor unions. Through these coordinated efforts, Tennessee aims to build a skilled workforce capable of supporting its nuclear energy goals and positioning the state as a leader in the industry. A comprehensive table with short to long-term goals is provided in the Appendix (Table 1: Summary of program components and development plan).

Key Findings: To advance competitiveness in nuclear energy, Tennessee must leverage current investments, state program integration, and industry coordination to ensure that the state has the most innovative and skilled nuclear workforce in the US and the world. A centralized backbone organization housed at ORAU is critically needed to achieve this goal.

Consensus Recommendation: The creation of the Tennessee Nuclear Workforce Center at ORAU is an essential infrastructure to support the ongoing integration and alignment of public-private workforce investments currently required by Tennessee's growing nuclear energy industry and to build a globally competitive nuclear innovation hub for the future. A globally competitive nuclear innovation hub will be a major driver of economic growth and shared prosperity for the citizens of Tennessee.

Building a Stronger Future: Comprehensive Recommendations for Tennessee's Nuclear Energy Sector

Tennessee's nuclear energy sector faces critical workforce development and communication challenges, including the lack of a central coordinating body, unclear labor demands, and ineffective marketing strategies. These issues, along with geographic disparities in training and insufficient data utilization, hinder the state's ability to attract and retain skilled workers. To address these challenges, strategic recommendations have been developed across key areas: governance, industry engagement, state and federal collaboration, academia, strategic communications, funding opportunities, and continuous improvement. Implementing these measures will strengthen Tennessee's nuclear workforce and position the state as a leader in the nuclear energy industry.

SECTION 1: TIMELINE AND MAJOR IMPLEMENTATION AREAS

Short through Long-Term Summary of Program Components and Development Plan: This comprehensive table outlines a range of plans from short-term to long-term, categorized across several key areas of focus. It covers governance, strategic planning, infrastructure and programming, state agencies engagement, industry engagement, evaluation and improvement, and outcomes, providing a clear roadmap for organizational development and growth. The breakdown allows stakeholders to understand the progression of initiatives and goals over time, from immediate actions to long-range objectives. By presenting this information in a structured format, the table facilitates better decision-making, resource allocation, and alignment of efforts across various departments and timeframes.

Components for Success	Near-Term 0-6 Months	Short-Term 6 – 12 Months	Mid-Term 12 – 18 Months	Long-Term 18 – 24 +Months
Governance	**Establish advisory council** Identify champions Approve programmatic documents including program plan, stakeholder management plan and financial plan	Determine initial workgroups "WG" and plan backbone organization Approve stage-gates based on program evaluation	Build out the backbone organization, evolve WGs to meet emergent strategy Approve stage-gates based on program evaluation	Approve stage-gates based on program evaluation
Strategic Planning	**Labor Demands:** Create a high-capital industry roundtable to identify current and future labor demands (ETEC) Develop all programmatic documents, including program plan, stakeholder management, and financial plan	**Evaluate Other Models for Best-Practices** Examples include Blue Oval City model as a potential framework **Funding Strategy** Design interagency infrastructure funding agreements	Update programmatic documents based on first-year evaluation	**Strategic Communication and Marketing Initiative for Nuclear Energy Awareness**
Infrastructure and Programming	**Criticality Center of Excellence** – evaluate the development Identify and catalogue existing assets, and identify gaps based on overall regional nuclear industry stakeholder	**TN Nuclear Energy Academic Alliance** form a collaborative academic network **Create a Pre-Apprenticeship and Apprenticeship Program**	**Establish a Framework / Platform for Knowledge Sharing** **Establish Nuclear Specific Adult Education Programming** with current workforce programs like the Workforce Innovation and Opportunity Act (WIOA)	**TN Nuclear Energy Academic Alliance** implement educational pathways (e.g. dual enrollment) **Create Short-Term Credential Programming**
State Agencies Engagement	Establish a POC for mid- and west- Tennessee	**Pilot State-to-State** working group for 8-states (TVA/ETEC)	**Comprehensive Online Interactive Platform for State Resources and Programs**	**Establish a Federal-to-State** working group
Industry Engagement	**Labor Demands:** Create a high-capital industry roundtable to identify current and future labor demands	Convene industry stakeholders at annual TN nuclear seminar	**Industry Case-Studies** to facilitate replication and knowledge transfer	**Industry** Implement learning exchanges
Evaluation and Improvement	**Shared Measurement System** – develop a set of common metrics and indicators to measure the success of TN nuclear energy education, training and workforce	Analyze baseline data to ID key issues and gaps	Develop high level shared metrics and/or strategies at SC level	Establish shared measures (indicators and approach) at SC and WG levels
Outcomes	Approved program plan and other documents Stakeholder identification and alignment and infrastructure gaps identified	All strategic plans implemented including programmatic staff hiring, funding and stakeholder management	Plans implemented to close all infrastructure gaps	All initiatives implemented and functioning

SECTION 2: GOVERANCE

Recommendation #1: Establish a Central Coordinating Body for Nuclear Energy Education, Training, and Workforce Development

The nuclear energy sector in Tennessee faces significant challenges due to the absence of a central coordinating body to support cross-sector collaboration and align workforce efforts. This fragmentation extends across state agencies, federal agencies, and stakeholders within Tennessee, hindering efforts to meet industry demands effectively. There is a pressing need for stronger leadership and coordination across the public, private, and academic sectors to create a cohesive strategy for nuclear energy education, training, and workforce development. Establishing a centralized coordinating entity would streamline efforts, reduce redundancies, and ensure a more efficient use of resources in developing Tennessee's nuclear workforce.

Key actions to implement this recommendation include:

1. Form a governing consortium with representatives from key stakeholders such as the Tennessee Department of Education, TVA, UCOR, ETEC, local and state government officials, industry partners, and educational institutions to oversee strategic direction and ensure alignment with industry needs.
2. Designate or establish a dedicated organization, such as ORAU, to serve as the backbone for the initiative, providing staff and resources to coordinate activities across the public, private, and academic sectors.
3. Create a Steering Committee for continuous oversight and establish working groups focused on specific areas like education and industry to facilitate collaboration across sectors.
4. Develop a comprehensive 5-year strategy with implementation plans and actionable areas for FY25-28, focusing on creating a cohesive approach to nuclear energy education, training, and workforce development.

Recommendation #2: Nuclear Cluster Workforce Definition

A comprehensive cluster analysis is essential to clarify and identify the multiple components required by a competitive nuclear sector and its varied workforce needs. This analysis should encompass expertise in legal and finance, construction, management, and other related fields. By defining the scope of the nuclear cluster workforce, Tennessee can better tailor its educational and training programs to meet the diverse needs of the industry. This holistic approach will ensure that the state develops a well-rounded workforce capable of supporting all aspects of the nuclear energy sector, from regulatory compliance, to nuclear construction, to plant operations and beyond.

SECTION 3: INDUSTRY ENGAGMENT

Recommendation #1: Understanding Labor Demands in the Nuclear Energy Sector

Tennessee's nuclear energy sector faces a critical challenge in understanding industry labor demands, which impacts effective workforce alignment and development. To ensure that the state's nuclear workforce remains adaptable and competitive in the rapidly evolving energy landscape, a comprehensive approach is essential. This strategy should begin with the establishment of an industry partnership involving high-capital organizations to provide crucial insights into upcoming workforce demands, labor strategies, and predictive models. A key component of this effort is the implementation of a public-private mechanism for predictive workforce analytics, which will forecast requirements across the entire nuclear ecosystem, extending beyond craft labor workers.

To address these challenges, we recommend the following actions:

1. Organize Quarterly Round-Table Discussions: Host discussions with representatives from high-capital industry stakeholders, potentially facilitated by organizations such as ETEC or TVA, to identify current and future labor demands in the nuclear sector.
2. Develop a Future-Focused Competency Skills Framework: Create a dynamic skills matrix that anticipates both current and emerging industry needs, ensuring that training programs align with these competencies.
3. Implement Comprehensive Competency Planning: Develop an integrated labor strategy that bridges identified skill gaps while addressing geographic disparities in training and employment opportunities across the state.
4. Enhance Program Sequencing: Improve coordination and timing of training programs to effectively meet evolving industry demands.
5. Monitor Global Market Trends: Continuously assess global market trends that impact the competitiveness of Tennessee's nuclear sector to inform workforce development strategies.

Recommendation #2: Evaluate Collaborative Models for Nuclear Education and Workforce Development

To enhance Tennessee's nuclear energy education and workforce training initiatives, we recommend evaluating models similar to the Blue Oval City framework. This model exemplifies effective collaborative partnerships between government entities and industry stakeholders, demonstrating how such alliances can drive innovation and meet workforce demands. By exploring these successful frameworks, Tennessee can identify best practices that may be adapted to its unique context.

Recommendations to develop this include:

1. Benchmark Successful Models: Research and analyze existing collaborative education and workforce development models in other sectors that effectively integrate partnerships among government, industry, and educational institutions.
2. Identify Key Performance Indicators: Establish metrics to evaluate the effectiveness of different models in meeting workforce demands and fostering innovation within the nuclear sector.

Recommendation #3: Bridging the Knowledge Gap: Enhancing Information Sharing and Retention in Tennessee's Nuclear Industry

The nuclear industry in Tennessee faces significant challenges in effectively sharing plans and transferring critical knowledge, particularly in nuclear safety. Knowledge retention has emerged as a pressing concern, exacerbated by difficulties in recruiting and retaining skilled workers in public programs. This issue is further compounded by knowledge gaps resulting from the retirement of experienced staff and insufficient documentation of tacit knowledge, lessons learned, and best practices accumulated over decades of hands-on experience.

The industry suffers from insufficient sharing of plans across various sectors, hindering collaborative efforts and strategic alignment. Moreover, there is a critical need for improved nuclear safety knowledge transfer to ensure the maintenance of high safety standards and operational efficiency. These challenges underscore the importance of implementing structured knowledge transfer programs, mentorship initiatives, and comprehensive documentation efforts.

To address the challenges of knowledge retention and transfer in Tennessee's nuclear industry, we recommend implementing a comprehensive collaborative framework. This framework will facilitate the sharing of best practices, promote innovation, and ensure the preservation of critical industry knowledge. Key components of this framework include:

1. Case Study Development and Dissemination: Create and distribute detailed case studies of successful industry programs to promote replication and knowledge transfer across the sector.

2. Collaborative Industry Platform: Establish a dedicated platform where nuclear energy stakeholders can share best practices, discuss challenges, and collaboratively develop solutions.
3. Learning Exchanges and Knowledge-Sharing Mechanisms: Implement structured programs for learning exchanges and knowledge sharing to support ongoing industry development and foster innovation.

By adopting these measures, Tennessee's nuclear industry will be better equipped to retain critical knowledge, enhance safety practices, and maintain operational excellence amidst workforce transitions and evolving industry demands. This collaborative approach will strengthen the industry's resilience and competitiveness in the long term.

SECTION 4: STATE AND FEDERAL AGENCIES

Recommendation #1: Bridging the Geographic Divide - Expanding Nuclear Industry Opportunities Statewide

There is a critical need to diversify and increase nuclear industry and workforce capacities and opportunities across the state, particularly in West Tennessee. This geographical disparity in training and employment opportunities creates a misalignment between program locations and job market demands across regions. Addressing this issue will ensure more equitable access to nuclear energy careers and contribute to the overall growth of the sector in Tennessee. By strategically expanding nuclear industry presence and educational programs in underserved areas, the state can tap into a broader talent pool and foster economic development in regions that have been historically overlooked in this sector.

To address the geographical disparities in nuclear industry opportunities and workforce development across Tennessee, we recommend implementing a comprehensive strategy to expand the sector's presence beyond East Tennessee.

1. Establish a Mid- and West-Tennessee Nuclear Energy Development Council: Create a dedicated council, modeled after the East Tennessee Economic Council (ETEC), to spearhead nuclear industry growth and workforce development initiatives in underserved regions.
2. Develop and implement a comprehensive Statewide Nuclear Workforce Engagement Strategy that includes satellite training centers, virtual learning programs, internship and apprenticeship opportunities, and a statewide awareness campaign to expand nuclear industry education, training, and career opportunities across all regions of Tennessee, particularly in areas without existing nuclear facilities.

Recommendation #2: Enhancing Information Sharing Across State and Federal Agencies

The nuclear energy sector faces significant gaps in information sharing both at the state and federal levels. Currently, there is no established mechanism for states to exchange best practices and lessons learned regarding workforce development and operational efficiency in their nuclear sectors. Additionally, the lack of a structured communication model between state and federal agencies further complicates collaboration, leaving states without essential support and guidance from federal resources. This fragmentation is exacerbated by the absence of a dedicated federal agency focused on nuclear energy workforce issues, leading to missed opportunities for synergy and innovation.

To address these challenges, the following recommendations are proposed:

1. Create a State-to-State Collaborative Model: Establish a framework for information sharing between states with nuclear energy sectors to facilitate the exchange of best practices, resources, and strategies.

2. Create a State-to-Federal Model: Develop a structured communication model for sharing information between states and federal agencies, ensuring that states receive timely support and guidance on nuclear energy initiatives.
3. Federal Interagency Model: Establish a collaborative framework among federal agencies to streamline communication and resource sharing related to nuclear energy, enhancing coordination and support for state-level efforts.

By implementing these recommendations, Tennessee and other states can foster a more integrated approach to workforce development and operational excellence in the nuclear energy sector.

Recommendation #3: Comprehensive Online Interactive Platform for State Resources and Programs

The absence of a unified framework for knowledge sharing across different sectors and departments hinders effective collaboration and resource utilization in Tennessee's nuclear industry. Siloed organizational programs lack visibility with other programs, cross-mapping, and integration, preventing complementary efforts from leveraging each other's strengths. This fragmentation leads to inefficient resource allocation due to a lack of mechanisms for identifying shared opportunities and aligning investments across isolated programs. Implementing a comprehensive knowledge management system and fostering inter-organizational collaboration would significantly enhance the state's ability to develop and maintain a skilled nuclear workforce.

To address the fragmentation of knowledge and resources in Tennessee's nuclear industry, we recommend developing a comprehensive online platform with two key components:

1. Internal Government Resource Mobilization Tool:
    - Map all state programs related to nuclear workforce development
    - Track funding streams and resource allocation
    - Identify opportunities for cross-agency collaboration and efficiency
2. Public-Facing Information Hub:
    - Consolidate information on nuclear education, training, and career opportunities
    - Provide easy access to state resources and programs
    - Offer a user-friendly interface for stakeholders to navigate available support

This dual-purpose platform will streamline internal operations, optimize resource utilization, and improve public access to nuclear industry opportunities in Tennessee.

SECTION 5: ACADEMIA

Recommendation #1: Enhance Tennessee's Nuclear Energy Leadership through a Specialized Center of Excellence

During the workshop, the Department of Energy Office of Environmental Management (DOE-EM) representative highlighted the potential for establishing a specialized Nuclear Energy Center of Excellence in Tennessee. This proposed center would not only focus on critical aspects of the nuclear energy sector within the state but also serve as a national hub for collaboration and coordination across the United States.

This concept aligns with Tennessee's growing prominence in nuclear energy, as evidenced by recent developments such as ORANO, USA's selection of Oak Ridge as the preferred site for a major uranium enrichment facility. The state's existing nuclear infrastructure, including assets like Oak Ridge National Laboratory, positions Tennessee favorably to lead this national initiative.

While the specific focus areas of this center require further deliberation, it could serve as a complementary resource to existing and planned nuclear energy projects both in Tennessee and across the country. By leveraging Tennessee's expertise and resources, this center has the potential to enhance the state's role as a leader in safe, clean, and reliable energy production while simultaneously becoming the nation's leading expert in nuclear energy innovation and policy.

This national hub would facilitate collaboration between states, federal agencies, and industry partners, positioning Tennessee at the forefront of nuclear energy advancement and solidifying its status as a key player in shaping the future of America's energy landscape. Preliminary recommendations included the following:

1. Consolidation of Expertise: Establish the center to bring together leading experts in nuclear safety and criticality, fostering collaboration and knowledge sharing across the industry.
2. Innovation in Risk Management: Foster innovative approaches to risk management at nuclear facilities, particularly focusing on the Department of Energy's Environmental Management (DOE-EM) complex.
3. Programmatic Guidance: Assist EM management with focused guidance on emerging safety basis issues and risk-informed decision-making.
4. Knowledge Management: Organize and maintain a comprehensive body of knowledge on nuclear safety, preserving lessons learned from the DOE-EM complex.
5. Benchmarking Successful Models: Research and benchmark successful Center of Excellence models from other sectors, particularly those that effectively integrate partnerships among state, local, and industry stakeholders.
6. Alignment with Strategic Objectives: Ensure that the center aligns with broader strategic objectives for nuclear safety and workforce development. Assemble a team of subject matter experts who can guide its initiatives while maintaining operational independence to maximize impact and effectiveness.

Recommendation # 2: Address Entry Barriers and Enhance Career Pathways in the Nuclear Energy Sector

Tennessee's nuclear energy sector faces significant challenges in workforce entry and career progression. There is a lack of clear information on prerequisites for nuclear careers, hindering potential candidates from understanding entry requirements. Insufficient coordination and ongoing communication among agencies working to create awareness and onboard prospective workforce participants exacerbate this issue. The sector suffers from a lack of feedback loops between agencies working on workforce awareness and industry, as well as between these agencies and education and training programs. This disconnect leads to misalignments in workforce development efforts. Career pathways and job requirements at various levels (e.g., entry-level, mid-career) lack clarity, impeding effective career planning. While there is a recognized need for personalized learning pathways and adult education programs tailored to the nuclear energy industry, budget constraints pose significant challenges in creating these essential programs. Addressing these interconnected issues is crucial for building a robust and sustainable nuclear workforce pipeline in Tennessee.

To address these critical gaps and build a robust, sustainable nuclear workforce pipeline, we recommend the following actions:

1. Establish a Comprehensive Apprenticeship Program:
    - Collaborate with the East Tennessee Apprenticeship Readiness Program and Labor Unions to develop a Department Pre-apprenticeship (K-12) and Apprenticeship Program.

- Implement K-12 outreach initiatives to raise career awareness in the nuclear field.
- Create opportunities for adults to explore nuclear energy as a viable career option.

2. Develop Tailored Adult Education Programs for Nuclear Workforce:
   - Design specialized adult education programs focused on nuclear workforce development, complementing existing general programs like the Workforce Innovation and Opportunity Act (WIOA).
   - Create curriculum and training modules that address specific skills and knowledge required in the nuclear sector, ensuring a more direct pathway to employment.
   - Collaborate with industry partners to align programs with current and future workforce needs in the nuclear energy sector.

Recommendation # 3: Educational and Curriculum Improvement
Tennessee's nuclear energy education system faces multifaceted challenges that significantly impede workforce development in this critical sector. A primary concern is the substantial misalignment between current educational offerings and the rapidly evolving needs of the expanding nuclear industry, creating a temporal disconnect that hampers the state's ability to meet emerging workforce demands. This issue is compounded by the insufficient focus on nuclear energy in the K-12 education system, where the absence of a comprehensive curriculum limits early exposure and interest in the field, potentially narrowing the future talent pipeline. Furthermore, there exist potential discrepancies between regulatory requirements and the content of existing educational programs, which may result in graduates being inadequately prepared to meet stringent industry standards. The absence of an adaptive curriculum mechanism exacerbates these issues, as it hinders the continuous updating of educational content to align with industry advancements and regulatory changes. This lack of agility in the educational framework poses a significant challenge to maintaining Tennessee's competitive edge in the nuclear sector. Addressing these interconnected gaps is not merely beneficial but essential for cultivating a well-prepared, adaptable, and innovative nuclear workforce capable of propelling Tennessee to the forefront of the national nuclear energy landscape.

Initial discussions with Tennessee state agencies revealed the feasibility of establishing the Tennessee Nuclear Energy Academic Alliance. This alliance aims to address preliminary challenges in the nuclear energy sector, including:

1. Create a Collaborative Network: Form a partnership among community colleges, universities, and technical schools to develop specialized nuclear energy education programs tailored to industry needs.
2. Coordinate Statewide Training Initiatives: Mobilize resources and efforts across institutions to address identified workforce requirements effectively.
3. Implement Diverse Educational Pathways Through Braided Models[1] (see Appendix B, Illustration 1) Introduce a variety of educational options, including high school dual enrollment programs, 2+2 pathways, and micro-credentialing initiatives, to better align with industry demands.
4. Develop Short-Term Credential Programs: Establish programs that facilitate quick entry into the nuclear industry, alongside certificate offerings designed to upskill professionals from related fields.

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[1] The braided river model is a metaphor for STEM workforce development that emphasizes inclusivity and diversity, illustrating multiple entry points and varying career pathways. Unlike the traditional pipeline model, it recognizes that individuals can adapt their careers based on new interests and responsibilities, reflecting the natural flow of a braided river.fields.by natural braided rivers, this concept emphasizes the multitude of routes leading to the same ultimate destination in STEM careers, providing a more holistic view of professional development in these fields.

SECTION 6: STRATEGIC COMMUNICATIONS

Recommendation #1: Promoting Nuclear Careers: A Comprehensive Communication Strategy for Tennessee

Tennessee's nuclear energy sector currently faces significant gaps in its communication and marketing strategies. There is no cohesive communications strategy, branding initiative, or marketing campaign aimed at raising awareness of nuclear energy careers and educational opportunities. This absence limits the sector's ability to effectively engage potential students, parents, and communities, particularly in rural, low-income, and marginalized populations. Without a well-defined narrative around nuclear energy, misconceptions persist, hindering efforts to attract a diverse workforce that can support the industry's growth and innovation.

To address these challenges, the following actions are proposed:

1. Implement a Targeted Marketing Campaign: Develop a campaign to promote nuclear energy careers and educational opportunities specifically aimed at students and parents.
2. Base Marketing on Labor Demand Feedback: Create marketing strategies informed by feedback regarding current labor demand needs within the industry.
3. Focus on Underserved Populations: Target communications to reach rural, low-income, and marginalized communities to ensure inclusivity in workforce development efforts.
4. Reshape the Nuclear Narrative: Work on enhancing public perception of the nuclear industry by developing a positive and informative narrative that highlights its benefits and opportunities.

SECTION 7: FUNDING AND OPPORTUNITIES

Recommendation #1: Funding and Resource Mobilization

Tennessee's nuclear energy sector faces significant challenges in securing adequate funding streams to support nuclear marketing, education, training, and entry-level employment initiatives. The lack of a comprehensive funding strategy analysis hampers efforts to identify and leverage potential financial resources effectively. There is a pressing need for improved resource mobilization and better interconnections of resources between state entities, industry partners, and non-profit organizations. Developing a robust funding strategy and fostering stronger partnerships across sectors will be crucial for sustaining and expanding nuclear workforce development efforts in the state.

To effectively address the challenges facing Tennessee's nuclear energy sector, it is imperative to develop a comprehensive strategy for funding and resource mobilization that enhances collaboration among state entities, industry partners, and non-profit organizations.

1. Create an Education, Training, and Workforce working group to secure funding collectively through diversifying funding plans (e.g., investors, foundations, federal, etc.) so that we are not reliant on state government funding. This group can develop comprehensive strategies to attract diverse funding sources, create synergies between education and industry needs, and ensure long-term sustainability of workforce development initiatives.
2. Pursue interagency infrastructure funding agreements to leverage resources, reduce duplication, and maximize the impact of investments across multiple sectors. These agreements can help streamline project implementation, share costs, and ensure a more comprehensive approach to infrastructure development.
3. Industry + state resource connected and mobilized via sector-based strategies. Implement targeted approaches to align industry needs with state resources, fostering collaboration between public

and private sectors. This can lead to more efficient resource allocation, tailored workforce development programs, and increased economic competitiveness within key industries.

4. Explore public-private partnerships (PPPs) to attract private capital and expertise for large-scale projects, potentially reducing the financial burden on government budgets while accelerating project delivery and improving long-term maintenance.
5. Investigate grant opportunities from federal, state, and local sources, including specialized programs for sustainable infrastructure, urban development, and climate resilience initiatives.
6. Develop a comprehensive asset management strategy to optimize the use of existing resources and prioritize investments based on lifecycle costs and benefits.

SECTION 8: EVALUATION AND IMPROVEMENT

Recommendation # 1: Data Analytics for Decision Making

The underutilization of existing state models and data hampers effective decision-making in the nuclear energy sector. There is a pressing need to increase industry participation in the design of data collection and analysis processes. By leveraging data analytics more effectively, Tennessee can make informed decisions about resource allocation, program development, and workforce strategies to support the growth of the nuclear energy industry. Improved data utilization will enable policymakers and industry leaders to identify trends, anticipate challenges, and capitalize on opportunities in the nuclear sector, ultimately leading to more targeted and effective workforce development initiatives.

To effectively leverage data analytics for informed decision-making in Tennessee's nuclear energy sector, we recommend implementing a comprehensive data strategy focused on collaboration, improved collection, and advanced analytics. Key actions include:

1. Establish an Industry-Government Data Partnership: Create a framework for collaboration between state agencies and nuclear industry stakeholders to design data collection processes, develop shared standards, and identify key performance indicators aligned with workforce development goals.
2. Evaluate and Enhance Data Infrastructure: Conduct a comprehensive assessment of current data collection, management, and sharing practices across the nuclear energy sector. Based on this evaluation, develop a centralized data repository to consolidate and integrate information from diverse sources, ensuring data integrity through automated validation processes. This approach will optimize data utilization, improve accessibility, and facilitate more effective decision-making and collaboration among stakeholders.
3. Enhance Data Analytics Capabilities: Utilize advanced analytics tools to process large datasets, develop predictive models for workforce needs, and apply machine learning to uncover insights.
4. Foster a Data-Driven Culture: Provide training in data literacy for decision-makers and establish regular review sessions to discuss insights and implications for resource allocation.
5. Continuous Improvement: Implement a feedback system to monitor the effectiveness of data-driven initiatives and adjust processes based on evolving industry needs.

APPENDIX

Appendix A – Collective Impact Phase 1 Methodology:

The methodology to address the critical need for an inter-agency collaboration among state agencies and other stakeholders, as well as resource mobilization/sharing and program mapping is described herein.

ORAU and GAP collaborated with Tennessee state agencies and the TNEAC to implement Phase 1 of Collective Impact: Assess Readiness, and part of Phase 2: Initiate Actions. From September to October 2024, ORAU and GAP:

1. **Conducted an Inventory Survey of State Agencies and TNEAC members (September):**
    - Compiled a comprehensive inventory of all nuclear training, education, and workforce development programs and assets
    - Identified primary barriers to cross-agency collaboration in creating a shared agenda, system, and metrics for nuclear training, education, and workforce development
    - Gathered recommended solutions from organizations to overcome these barriers
2. **Hosted In-Depth Interviews with State Agencies and TNEAC Members (September – October):**
    - Assessed program impact and evaluation methods
    - Explored information sharing and inter-agency collaboration practices
    - Examined existing collaborative efforts and partnerships
    - Investigated resource allocation and support mechanisms
3. **Facilitated an In-Person Collective Impact Workshop for Phase 1 and Part of Phase 2 (October):**
    - Convened all stakeholders to expand on the inventory survey and in-depth interview findings
    - Identified potential champions to form a cross-sector steering committee
    - Mapped the resources and program landscape, analyzing baseline data to identify key issues and gaps
    - Initiated discussions on recommendations and next steps for the TN Nuclear Energy Workforce Center

Appendix B: Illustration 1 – Braided Model

The braided river model is a metaphor for STEM workforce development that offers a more inclusive, diverse, and equitable perspective on career paths. Unlike the traditional pipeline model, it illustrates multiple entry points, varying pathways, natural breaks, converging paths, and evolving careers. This model recognizes that individuals can enter the workforce from diverse educational backgrounds, progress at different speeds, experience career pauses, and adapt their paths in response to new interests, personal responsibilities, and further education. Inspired by natural braided rivers, this concept emphasizes the multitude of routes leading to the same ultimate destination in STEM careers, providing a more holistic view of professional development in these fields. Information on the model is found here: https://eos.org/opinions/reimagining-stem-workforce-development-as-a-braided-river