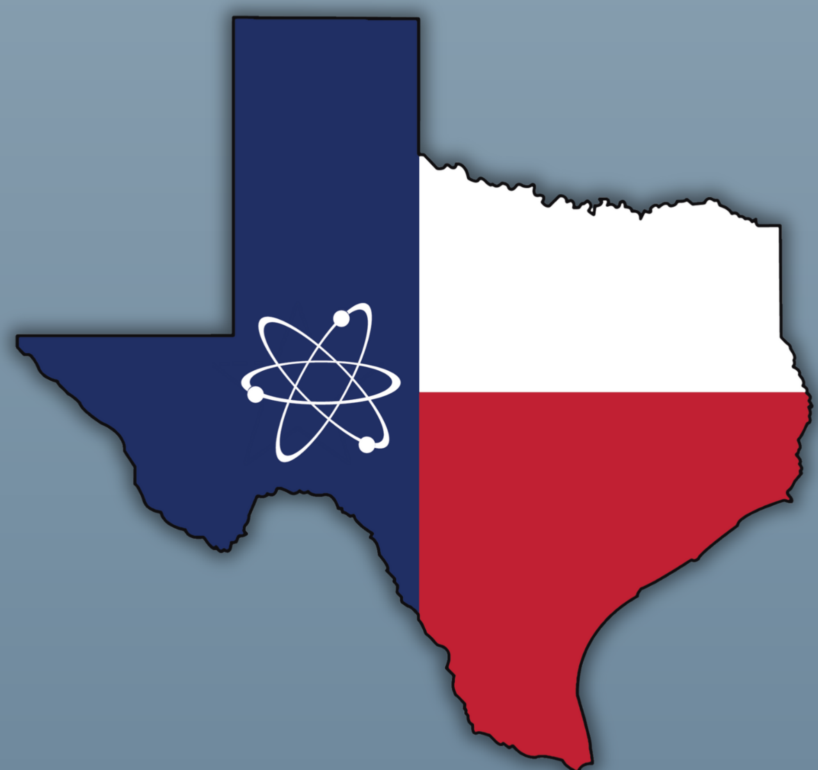
TEXAS ADVANCED NUCLEAR REACTOR WORKING GROUP

NOVEMBER 2024

Deploying a World-Renowned Advanced Nuclear Industry in Texas

Considerations and Recommendations for Action



GOVERNOR GREG ABBOTT

August 16, 2023

Kathleen Jackson, P.E.
Interim Chair, Public Utility Commission of Texas
170 I North Congress Avenue, 7th Floor
Austin, Texas 787

Dear Ms. Jackson:

As our state grows, so must our electric power generation. To maximize power grid reliability, the Public Utility Commission of Texas (PUCT) should consider all forms of dispatchable power, including nuclear energy. In particular, the PUCT should evaluate advanced nuclear reactors to determine if they can provide safe, reliable, and affordable power to our grid.

I instruct the PUCT to establish a working group to study and plan for the use of advanced nuclear reactors in Texas. This working group should focus on understanding the state's role in deploying and using advanced nuclear reactors; consider all potential financial incentives available; determine nuclear-specific changes needed in the Electric Reliability Council of Texas (ERCOT) market; identify any federal or state regulatory impediments to development; and identify how the state can streamline and accelerate permitting for the building of advanced nuclear reactors in Texas. The working group should also engage Texas supply chain manufacturers to foster homegrown development of this technology in our state.

The working group should include and coordinate with stakeholders with applicable experience, relevant state agencies and institutions of higher education, appropriate federal agencies, and current and potential future market participants in order to best understand how Texas can encourage the timely implementation of advanced nuclear reactors. Further, I direct the working group to identify any federal incentives available for the state and stakeholders to access and utilize. Additionally, the working group should coordinate with ERCOT to begin solving the technical challenges of incorporating advanced nuclear energy into the ERCOT grid.

Foundational to these charges is the safety of Texas communities, and it is critical that this report address advanced nuclear reactor safety. Finally, I charge the working group to submit a plan and recommendations to my office by December 1, 2024, outlining how Texas will become the national leader in using advanced nuclear energy.

Nuclear energy is a proven, reliable, and dispatchable generation resource. It will become even more critical as Texas' need for reliable power continues to grow. The State of Texas must plan now to best harness these new advanced technologies and ensure the future of the Texas grid and our position as the energy capital of the world.

Specifically, I ask Commissioner Jimmy Glotfelty to lead this effort as he is already a leader in this area. Please coordinate closely with my office as your work progresses. Thank you for your commitment and service to Texas.

Sincerely,

Greg Abbott
Governor

GA:tb

[Full interchange document set](#)

Jimmy Glotfelty
Commissioner

Greg Abbott
Governor

Public Utility Commission of Texas

November 18, 2024.

Governor Abbott,

It is our pleasure to submit these recommendations after judiciously following the seven factors laid out in your August 16, 2023 letter. The Texas Advanced Nuclear Reactor Working Group is proud to lay out findings based on months of meetings and public input, and ahead of the original schedule.

Texas is well-poised to become the national, if not global, leader in using advanced nuclear energy technologies. Texas has the industrial and development needs — from oil & gas production to data centers and a burgeoning Artificial Intelligence sector — with demand growth projected at 8% a year for the next decade. Advanced nuclear is a viable solution to lead the way to provide the safe, resilient, reliable, dispatchable and steady source of energy the state and its citizens need.

The fundamental challenges are economics and federal licensing timeframes, neither of which the state can directly change. However, the Working Group has made several recommendations on incentives, including to the supply chain as well as ways to prove up the state's role as a regulatory and economic leader in this new innovative technology.

____
Commissioner Jimmy Glotfelty,
Public Utility Commission of Texas

EXECUTIVE SUMMARY

Texas is the energy capital of the world. Strategic action will position our state to also lead in the advanced nuclear industry.

As the largest energy-producing state in the nation, Texas is ready to build and develop a successful nuclear power industry. Our state has all the resources necessary to lead in this critical industry – the workforce to support large construction and manufacturing projects, the will to navigate the regulatory environment, the funding for investment, and 61 existing sites evaluated and ready for potential use. Texas must deploy a coordinated nuclear power strategy to enhance energy security and grid reliability, capture economic development opportunities and first-in-the-nation advantages, and cement our national and global energy leadership.

Texas Advanced Nuclear Reactor Working Group

At the direction of Governor Greg Abbott, the Texas Advanced Nuclear Reactor Working Group, comprised of over 100 experts and stakeholders, dedicated roughly 50,000 hours over the past year to shape Texas as a national and global leader in advanced nuclear technology. This report highlights key recommendations, opportunities, and strategies to position Texas as No. 1 in the advanced nuclear industry.

EXECUTIVE SUMMARY

5 Benefits to Advanced Nuclear Power in Texas

1. Enhanced Energy Security

Advanced Nuclear Reactors (ANRs) will support Texas' growing energy needs – providing clean, reliable power for urban centers, ports, oil and gas regions, industrial facilities, data centers, and military bases. This will strengthen both energy security and national security.[1]

2. Improved Grid Reliability

Nuclear power is more reliable than coal, wind, and solar, offering the resilience essential for everyday use and extreme weather conditions. [2]

3. Economic Development & Industry Opportunities

ANRs can co-locate with data centers and support heavy industries by providing process heat, powering desalination plants, and electrifying oil fields. This will create new, good-paying jobs, increase production, and grow paychecks across Texas. According to a Bureau of Business Research (BBR) report,[3] a moderate small modular reactor (SMR) deployment by 2055 could result in:

- An annual average of 148,000 people employed directly and indirectly by the new SMR industry in construction, operations, and manufacturing.
- Over $50 billion in new economic output for Texas.
- Over $27 billion in income for Texas workers.

4. First-In-The-Nation Advantages

Texas has the chance to lead the national competition[4] in advanced nuclear power. Being the first state with an efficient ANR strategy will bring jobs, manufacturing support, & supply chain gains.

5. Global Market Potential

The global nuclear market is projected to triple by 2050.[5] Establishing Texas as the preferred supplier for U.S.-based ANR technology will open international opportunities and offer an alternative to Chinese and Russian nuclear reactor technology for allies and partners.

EXECUTIVE SUMMARY

Time to Lead

With enhanced safety, scalability, and integration potential, ANRs are a key solution for Texas' energy reliability and stability to meet growing demand. Texas can lead by cutting red tape and establishing incentives to accelerate advanced nuclear deployment, overcome regulatory hurdles, and attract investment to solidify Texas as the global nuclear energy hub.

"I'd like to see our policymakers appreciate the value of being a powerhouse when it comes to nuclear energy. We ought to be... taking a moonshot approach to being the nuclear energy technology supplier of choice to the entire free world."

–Bill Flores, Chair of the Electricity Reliability Council of Texas and former US Representative

7 LEGISLATIVE RECOMMENDATIONS

The Working Group's recommendations that follow target critical nuclear industry issues in Texas with possible legislative solutions to bring ANR projects to Texas.

1	**Texas Advanced Nuclear Authority** *A non-regulatory entity to coordinate Texas' strategic nuclear vision, implement ANR policy recommendations, and manage potential funds and oversight of state nuclear incentive programs.*
2	**Texas Nuclear Permitting Officer** *A single point of contact for advanced nuclear reactor developers and associated businesses to navigate permitting.*
3	**Workforce Development Program for Community Colleges and Universities** *Coordination plan between workforce, education, and industry to support a homegrown nuclear workforce in Texas capable of meeting ANR industry and Texas energy demand.*
4	**Texas Advanced Manufacturing Institute** *Designed to develop and foster a nuclear ecosystem in Texas.*
5	**Texas Nuclear Public Outreach Program** *A communications and public engagement plan to inform and educate Texans about the benefits of advanced nuclear power and reactor development.*
6	**Texas Nuclear Energy and Supply Chain Fund** *A direct grant cost-sharing program to incentivize early development and siting, and support supply chain and manufacturing capacity readiness.*
7	**Texas Nuclear Energy Fund** *An appropriation to a fund, modelled after the existing Texas Energy Fund, explicitly for advanced nuclear power to overcome the funding valley project developers face in Texas.*

Questions and requests for additional information should be directed to Commissioner Jimmy Glotfelty and his staff at the Public Utilities Commission of Texas via: CommissionerGlotfelty@puc.texas.gov

CONTENTS

Texas Advanced Nuclear Reactor Working Group

On August 16, 2023, Governor Greg Abbott directed Commissioner Jimmy Glotfelty to establish the Texas Advanced Reactor Working Group to study and plan for the use of advanced nuclear reactors (ANRs) in Texas. Following that directive, Commissioner Glotfelty convened experts and stakeholders over the course of the next year to study issues related to ANRs and produce this report along with its legislative recommendations. This report outlines the findings of the workgroup and highlights the opportunities for the state to become a national leader in ANRs through a strategic course of action.

Background

Based on current demand growth projections, Texas has a unique opportunity to integrate ANRs into its' future generation portfolio. Electric Reliability Council of Texas' (ERCOT) streamlined interconnection model, projected demand growth, and independent and deregulated market structure, coupled with Texas' friendly regulatory environment, makes Texas an attractive investment for capital.

Texas is Already a Nuclear State

- **Nuclear power**. Texas is home to two nuclear power plants that generate over 5 GW of electricity or 10% of energy on the ERCOT grid: two units at Comanche Peak Nuclear Power Plant and two units at the South Texas Project have demonstrated exemplary performance, resilience during extreme weather, and safety. Furthermore, the Pantex Plant near Amarillo, TX, is the primary U.S. nuclear facility that maintains the safety, security, and reliability of the U.S. nuclear stockpile.
- **Higher education and medicine.** Texas is home to two world-renowned nuclear degree and research programs and the newest, privately funded research reactor. Many other colleges and universities in Texas have top-tier programs tailored towards specific attributes of the safety, security, and operations of nuclear plants. Nuclear medicine is a dominant tool in every hospital across the state and Texas medical research institutions are world renowned for their innovation.
- **Uranium mining.** Uranium mining for the nuclear fuel supply chain is growing across the state. Texas has one of the most suitable uranium deposits for extraction in the U.S., and is a preferred source of North American yellowcake. Texas' uranium reserves account for 8% of known U.S. uranium.

- **Regulatory oversight.** Texas has 3 state agencies, and a low-level radioactive disposal site (through an interstate compact) that currently regulate radioactive materials.

See Appendix D for more on Texas' existing nuclear assets.

Capacity Realities and Future Demand Growth

Over the last decade, Texas has been one of the fastest-growing states, both in population and gross domestic product, driving unprecedented increases in power demand. Summer power demand in the ERCOT region has increased an average of 30% over the last 10 years, a surge driven by expanding urban centers, rapidly increasing industrial activity, and economic expansion.

Going forward, ERCOT projects that absolute and seasonal peak demands will surpass previous years, with summer peak demand nearly doubling the current all-time record set on August 10, 2023, by 2030. Across the state, manufacturing and increased electrification of various sectors drive this growth. Aurora Energy Research's 2024 report on ERCOT growth suggests that all regions of the state could see almost 100% increases in demand by 2050.[6] (Figure 1)

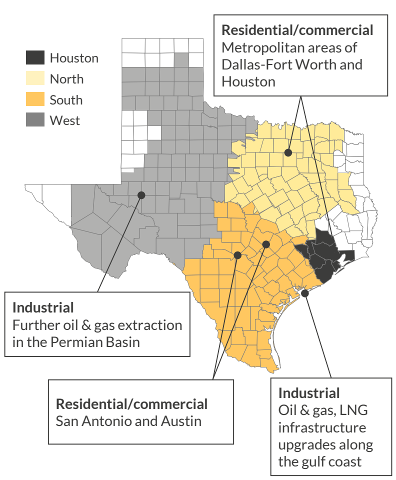
Figure 1. ERCOT Load Growth Creates Business Opportunities

Central market-level outlook - ERCOT Load Growth

All ERCOT regions experience load growth; West Texas mostly impacted by population growth, Permian Basin electrification and cryptocurrency mining

AURORA

Key load locations in ERCOT



Load zone	Major load drivers	Sensitivities
Houston	▪ Population growth ▪ Rural to urban transition ▪ Office and retail space ▪ Space heating & cooling ▪ Data center growth	▪ Oil & gas processing capacity and price dynamics ▪ Refining capacity additions ▪ EV adoption ▪ Grid-connected electrolyzers
North	▪ Population growth ▪ Urban residential, retail & office growth in DFW ▪ Space heating & cooling ▪ Data center growth	▪ Manufacturing load ▪ Grid-connected electrolyzers ▪ EV adoption
South	▪ LNG expansion ▪ Urban growth in Austin and San Antonio ▪ Space heating & cooling ▪ Data center growth	▪ Number of LNG processing facilities and proportion of load that is self served ▪ Grid-connected electrolyzers ▪ EV adoption
West	▪ West Texas population growth (highest CAGR in Texas) ▪ Oil and gas electrification in the Permian Basin ▪ Cryptocurrency mining	▪ Electrification of oil and gas operations ▪ Grid-connected electrolyzers ▪ EV adoption rate, especially in rural areas

1) Includes Bitcoin mining load.2) Total load breakdown, therefore does not include rooftop solar adjustment or demand side response.

Sources: Aurora Energy Research, ERCOT, US EIA , Texas Demographic Center

Become the Flagship

Building an early, robust order book with policies to accelerate ANR projects provides necessary market signals to justify building construction, supply chain, and manufacturing capacities in Texas. Texas has leading supply chain and manufacturing capacity due in large part to local heavy industry operations from oil and gas. Pivoting existing capacity and scaling up local, specialized facilities will drive down costs, making Texas the preferred supplier for national and global ANR projects. This will further enhance Texas' economic development through an advanced nuclear industry and making Texas the flagship for reshoring the domestic industrial base for the ANR industry.

What Advanced Nuclear Power Can Do in Texas

Nearly 500 nuclear power reactors have operated worldwide since 1958.[7] Currently, they provide around 20% of the nation's power. According to the Department of Energy (DOE),[8] nuclear power:

- Generates clean, carbon-free energy.
- Has had a consistent cost structure over decades, unlike natural gas that can have drastic price spikes.
- Provides firm power.
- Provides power with low-land use (more than 100x less than solar and wind per MWh generated per year).
- Has lower transmission requirements than distributed or site-constrained sources.
- Can repurpose retiring fossil fuel electrical transmission assets and workforces.
- Provides huge regional economic benefits—more than 2x more permanent onsite jobs per gigawatt (GW) than coal and the highest median industry wage among generation types.
- Provides a wide variety of use cases to enhance grid flexibility—all of which are valuable for Texas.

ANRs technical advancements are challenging existing nuclear conventions, with designs that are safer, smaller, promote interoperability with existing resources, reduce land use, and solve the challenges of a modern, growing grid better than any other form of energy. See Figure 2 for the range of advanced nuclear reactors in development and Appendix E for a high-level summary of technical information.

Figure 2. Types of Advanced Nuclear Reactors

Safety

Nuclear power is safe; advanced nuclear power is even safer.

For decades, the U.S. has safely operated nuclear reactors across the country under the U.S. Nuclear Regulatory Commission (NRC), and today 94 nuclear reactors operate at 54 sites.[9] The NRC regulates the safety and security of nuclear power plants, not individual states. Nuclear power is distinct from the rest of the energy sector in this way. The NRC is responsible for regulating commercial nuclear power plants "through licensing, inspection and enforcement of its requirements."[10] NRC has overseen the safe operation of more than 5,000 MWe of nuclear power in Texas for nearly four decades.[11]

Advanced nuclear reactors are built with a "defense-in-depth" approach, meaning there are multiple, layered safety systems and features that enhance natural, physics-based design and ensure the continued, safe operation of a plant long into the future. The keys to success include high-quality manufacturing and construction; testing and monitoring equipment; layered and distinct redundant systems; confinement of fuel effects and damage; and equipment in place to prevent human failure and operational disturbances.[12] In addition to the defense-in-depth approach, decades of operating experience and trained personnel with a strong safety culture ensure existing nuclear plants will continue to operate safely.

The NRC's extensive safety review before approving designs includes a review of:

- External hazards (nearby facilities, hydrology, seismology)
- Reactor fuel
- Reactivity control and reactor shutdown
- Primary coolant and decay heat removal
- Instrumentation and control
- Radiation protection for both workers and the public
- Accident analyses
- Operational programs (emergency plan, security, operator training).

Passive Safety Systems

ANR designs are also regulated by the NRC and built with a defense-in-depth approach to ensure safety and security.[13] As a result of design improvements and simplifications, many ANR designs are increasingly and reliably safe. Yet, these technological advancements surpass our 1970's technology, and the NRC does not yet have the specific experience or processes in place to evaluate their efficacy in a timely fashion.

New passive safety systems on Generation III+ and Generation IV nuclear reactors are designed to enhance safety by relying on natural forces (like gravity, convection, and natural circulation) rather than mechanical or human intervention. These systems help ensure that reactors remain safe even in the event of power loss or failure of active safety mechanisms. These innovations are aimed at making nuclear reactors safer and more resilient to potential failures, particularly in emergencies when power is unavailable or active systems might be compromised.

> **"Efficiency and safety are not mutually exclusive."**
>
> –Maria Korsnick, President & CEO, Nuclear Energy Institute

The NRC has a licensing process around specific safety features of specific designs that result in certain safety outcomes, instead of defining a safety outcome and allowing companies to innovate on how to achieve it across designs. Since ANRs do not easily map to existing nuclear licensing frameworks, first-of-a-kind (FOAK) ANRs face slower licensing processes and a disproportionate financial burden on what is a superior, safer product. The NRC is working to release a new licensing pathway by mid-2025; known as Part 53, this process will be technology agnostic and more efficient, predictable, and representative of the safety cases new designs pose.[14]

Building a Commercially Viable ANR

This section includes a snapshot of the process for building an ANR. See Appendices D and E for a more detailed discussion of the process and related regulatory permitting/approval and government funding options.

There are four phases of development for a reactor:

1. **Reactor design** - A one-time allocation of time, expertise, and other resources.
2. **Site selection** - Screening sites for suitability centers on health and safety, the ecological and socioeconomic environment, and various costs.
3. **Construction** - A process that spans preparation, manufacturing, and construction activities and becomes more integrated and efficient when supply chain and manufacturing facilities are in closer proximity to the reactors.
4. **Commissioning** - A wide range of activities to bring a nuclear facility into service, including verifying the design, performance, and safety of all systems and equipment.

In most of the four phases, there are regulatory licensing and approvals, which can vary depending on the specific project and authorizations being targeted.

Barriers to Financial Viability

In the development process, barriers to financial viability include:

- Regulatory and licensing complexities that can be time- and resource-intensive and high risk for developers and investors.
- Construction and manufacturing inefficiencies connected to skilled labor shortages, supply chain delays, and an immature industrial base.

Despite the growing need for reliable and firm energy capacity, there are still significant barriers to unlocking private capital to invest in new ANR projects. The lynchpin of a flourishing ANR industry is an investor-friendly environment, one in which developers can accurately assess an ANR project's risk and plan on a specific return prior to deploying capital. Regulatory, construction, and manufacturing hurdles must be clear to bridge FOAK development reactors to bankable subsequent or nth-of a-kind (NOAK) commercial products.

Regulatory Barriers and Recent Gains

Historically, the licensing process has been a very resource-intensive and high-risk endeavor for investors. This outcome is often accentuated as ANR developers raise unique regulatory questions resulting in uncertain and disproportionate time and money spent on the NRC licensing processes.[15] While companies like Kairos and Natura Resources seem to have figured out how to navigate this maze by leaning on iteration and novel commercial deployment models, longer and more uncertain licensing and approval processes continue to make it difficult for the financial community to deploy capital to ANR projects.

The federal government has made regulatory burden reduction a priority and is actively taking steps to address it for ANRs. In July 2024, Congress overwhelmingly passed the ADVANCE Act calling on the NRC to streamline the licensing process for new reactors and fuels. This reform is intended to reduce regulatory review costs, expedite applications, develop new risk-informed guidance for regulating advanced reactor technologies, and generally improve commission efficiency.[16]

Construction and Manufacturing Barriers

Cost overruns during the project implementation on the most recent nuclear construction project in the U.S., Georgia Power's Vogtle Units 3 and 4, were largely driven by engineering, procurement, and construction slip, accounting for 68% of the cost increases.[17] Schedule slippage was driven by rework and remediation, supply chain delays, and low labor productivity due to shortages in skilled labor. These schedule misses resulted in unplanned financing costs greater than 20% and the bankruptcy of the initial project contractor, Westinghouse. States with manufacturing, supply chains, and skilled workforces with complementary heavy industry experience already in place will do better managing operational challenges and reducing overall project costs than ones with an immature industrial and workforce base.

Texas can overcome these barriers with efficiencies and experience, including seeking permitting/approvals strategically; investments in pre-project planning and best practice project management safeguards; savings in build time and costs including the dramatic time and cost savings expected for NOAK reactors (subsequent builds after first-of-a-kind reactors have paved the way it is reasonable to expect an overnight capital cost of 60%+) as well as expected after standardization or learning by doing; and supply chain development and modularization.

Public Funding Available

Recognizing the chasm between regulatory uncertainty and early project financing for novel ANRs as well as the imminent need for clean, firm, reliable energy, some states have made grants, loans, and tax credits available to advanced nuclear technologies, in addition to a federal Investment Tax Credit (ITC) that can be up to 50% if the site is in an 'energy community. See Appendix F for details on available federal funding streams.

Table 1. Recent Advanced Nuclear Funding in Other States

State	Amount	Program
Tennessee	$60 million	Retain and attract nuclear supply chain companies to eastern TN.
	$350 million	Tennessee Valley Authority's board has approved funding to support its continued design work and development of potential SMRs at its Clinch River site near Oak Ridge, TN.
North Carolina	up to $75 million	Early Site Permitting
Kentucky	$20 million	Fund the Nuclear Authority
Wyoming	$10 million	Micro reactor study
	$150 million	The state legislature appropriated $100M in 2022 + $50M in 2023 to the Energy Matching Funds program administered by the Wyoming Energy Authority. The program is designed to spur innovation and bring transformative energy projects to WY.
Virginia	$2 million	Nuclear Innovation Hub
Washington	$25 million	Early Site Permitting
South Carolina	$40 million	Battelle Alliance supporting nuclear workforce development
Ohio	$750,000	Nine-member Governor-appointed board

Texas Momentum and Readiness

Active ANR Projects and Enthusiasm for More

A recent poll by our Working Group to the Texas Industrial Energy Consumers (TIEC), a membership-based organization representing large industrial manufacturers and chemical plants in Texas on electric consumer issues, indicated that most facilities are already engaged with ANR developers in some capacity and a large majority would consider installing a behind-the-meter ANR to power their facilities. This polling points to an enthusiastic local market for homegrown ANR designs and related construction capacity.

The Texas business community is already at work integrating the advanced nuclear industry into its grid and economy. There are three active ANR development initiatives, demonstrating innovative commercial deployment strategies, industrial heat partnerships, and conversion of existing manufacturing and supply chain capacity to meet advanced nuclear industry needs.

Natura Resources, in partnership with Abilene Christian University, is in the process of building their molten salt advanced nuclear research reactor, MSR-1, in Abilene, TX. Unlike commercial and power generating reactors, research reactors like MSR-1 are not subject to NRC licensing fees. Research reactors are also smaller than their commercial counterparts, reducing risk in the licensing process while developing competency for the licensee and the regulator to license larger and commercial reactors utilizing the same technology. **To date, Natura Resources' MSR-1 system is the only advanced nuclear research reactor in the U.S. to undergo review with the Nuclear Regulatory Commission.** It is being licensed under 10 CFR Part 50. The construction permit (CP) application was submitted in August 2022 and approved by the NRC in September 2024, a roughly 24-month review. The operating license (OL) application will be filed with the NRC next and is anticipated to require another 24-month review.

Dow Chemical and X-Energy partnered in collaboration with the Advanced Reactor Demonstration Program (ARDP) to build a series of XE-100 advanced reactors at the Dow petrochemical plant in Seadrift, Texas. Once completed, the X-energy reactors will provide both electricity and steam that can be used for industrial applications. The XE-100 is a high temperature gas reactor designed to operate as a single 80 MW electric unit or as part of an optimized four-unit plant delivering 320 MW for power and process heat. **The Seadrift project is poised to be the first, grid-scale SMR at an industrial site in North America.** The project is currently in pre-application engagement with the NRC, with XE-100 construction expected to begin in 2026. This X-Energy and Dow partnership is a prime example for how Texas can innovate to maintain its leadership and dominance in the chemical sector, while maintaining a stable grid and reduced emissions.

Shepherd Power is a newly established business under NOV, a Houston-based global leader in manufacturing and delivering engineered equipment and technology solutions to upstream oil and gas, renewables, and other heavy industry sectors of the global economy. Shepherd Power plans to own and operate microreactors supplying clean heat and power to support the oil and gas industry. They expect initial deployments of microreactors to be operating in the field by 2030, with a sharp ramp up thereafter to several hundred reactors. **The Shepard Power**

project is actively engaged with the NRC on developing a commercially viable licensing pathway for microreactors.

Immediate Siting Opportunities for ANRs in Texas

Through the efforts of the Working Group, the Texas PUCT is interested in reducing the risk of nuclear deployment decisions by creating a portfolio of deployment locations that meet site selection requirements for the future deployment of new nuclear energy.

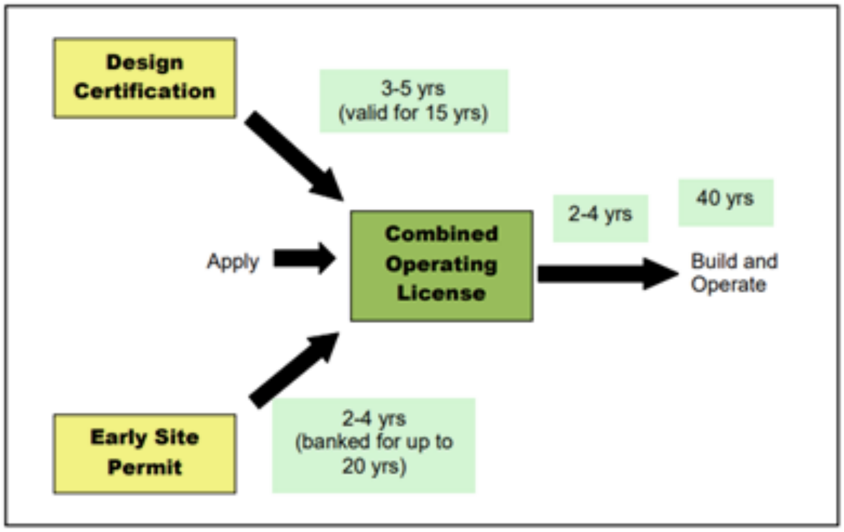
Oak Ridge National Lab Screening Analysis of 61 Sites Across Texas

There are existing sites in Texas ready for advanced nuclear industry consideration. In May 2024, Oak Ridge prepared site assessments on 21 closed or closing coal plants in TX, based on a national effort by Idaho National Lab's GAIN program. In addition to 'coal to nuclear' which is discussed in detail by OR-SAGE in the reports described in Appendix C, there are other strategic locations that are suitable for ANR projects. In August 2024, the Working Group sent 40 additional strategically chosen sites for evaluation. Factors such *as Ports, State owned lands, high growth areas, and industrial complexes* were considered. Most of the 40 sites evaluated should be amendable to consideration for ANR siting.

Oak Ridge provided evaluation assistance to the Working Group to evaluate suitability of advanced nuclear technologies to meet siting criteria from the Nuclear Regulatory Commission (NRC) and associated guidance documents including the Electric Power Research Institute (EPRI) siting guide and other proprietary datasets. The Oak Ridge-Siting Analysis for power Generation Expansion (OR-SAGE) tool utilizes the NRC siting criteria in its methodology, so it provides a quick easy screen for sites across the state. This tool uses a wide array of GIS data sources to identify candidate areas for ANR technology. More information on the full reports can be found in Appendix C.

Another siting tool available is **Early Site Permits** (ESPs). Pursuing ESP work in conversion of retired coal to nuclear or other sites that would help gain investor confidence includes front end engineering and design work necessary to move a project from concept to reality (preparation of a license application). See Figure 3.

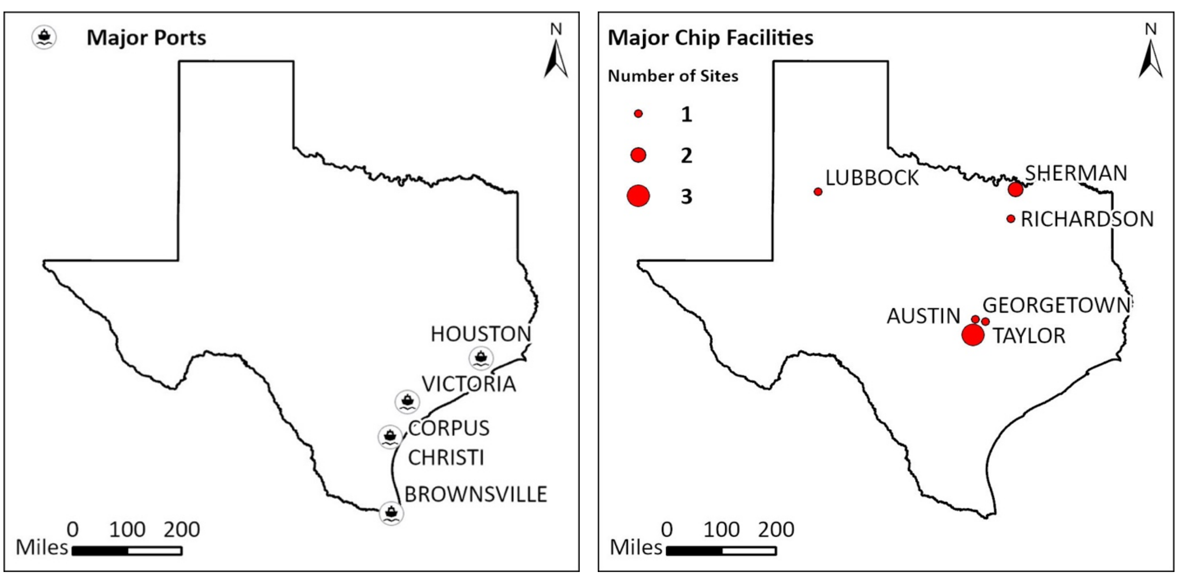
Figure 3. Early Siting Permitting Timeline and Time Savings



Source: Pacific Northwest National Lab, Policy Options for Nuclear Waste Management: Sustainable Solutions for Expanded Nuclear Energy (Sarah Widder, August 2009).

Figure 3 shows that to speed up the process of nuclear plant construction, a site permit should be filed at the same time design certification is being reviewed by the NRC. This will not happen on a large scale unless the public policy derisks the project through support for early site permits. With new reactor designs that have never been approved, the likelihood of private capital flowing into a site permit where the design is not known is near zero. The state can assist by supporting the studies and analysis needed to complete early site permit submissions.

Figure 4. Siting Opportunities in Texas



Several areas of Texas are likely candidates for ANR development:

1) ***Texas Ports***

The Ports and their associated industries, like Liquified Natural Gas (LNG), facilities carbon capture, hydrogen facilities and cruise terminals, need additional generation sources to provide resilient energy to meet future large load customers' demands. ANRs offer Texas' Ports a unique opportunity to enable continued growth.

COASTAL:

- **Galveston** will need additional resilient electricity to the island to serve future large load customers like upcoming LNG facilities and cruise terminals.
- **Port of Corpus Christi Authority** is designated by the Department of Defense as a strategic military port, providing surface deployment and distribution for strategic military cargo worldwide, bolstering their need for resilient power to support the strategic military establishments and growing seaport trade at the Port of Corpus Christi that accounted for 11.3% of the seaport trade, or about $29.5 billion in 2018.
- **Beaumont** is home to a petrochemical industrial complex. Chemical and other large users are very interested in the behind the meter applicability, as shown in the survey discussed elsewhere.
- **Houston Ship Channel** is a critical line to goods' transport and commerce with at least 200 countries.

RIO GRANDE VALLEY: The Port of Brownsville is experiencing growth in power-intensive industries including LNG, hydrogen and oil and gas, and Space X.

INLAND: In recent years, a Port of Victoria site was assessed for nuclear, and could be revisited.

2) ***Government/University Lands*** some of these were evaluated by ORSAGE and could be more cost efficient due to reduced real estate costs provided by co-location.

3) ***Industrial Complexes*** are prime locations due to their need for 24/7/365 power which is best provided by ANRs in addition to the steam/heat potential behind the meter.

4) ***Houston area*** is an 'energy island' in need of local resilient energy, especially in hurricane season.

5) ***Permian Basin*** has remarkable needs for electricity for its operations production. ANRs can not only meet that need but also help alleviate some transmission build needs and help reduce oilfield produced water injection by de-salinizing it for useful purposes.

6) ***Non-ERCOT areas*** are served by vertically integrated utilities who have different capital and rate structures as well as nuclear presences in other states.

7) ***Central Texas*** is home to the largest data center cluster in the State, access to universities and fast-growing population.

8) ***Metroplex*** is home to Alliance Airport/Industrial Complex/Hillwood. Second largest data center cluster in the State with more projected to operationalize.

RECOMMENDATIONS

Legislative Recommendations

Built upon an in-depth understanding of Texas industries, capacities, and needs as well as our examination and experience in the advanced nuclear field, the Texas Advanced Nuclear Reactor Working Group presents 7 legislative recommendations that strategically build and accelerate the advanced nuclear industry with Texas at the helm.

Provided is a consolidated list of recommendations. Following are one-pagers for each item that legislators and stakeholders may wish use moving into the 89th Legislative Session and beyond. Each one-pager includes a stated challenge, and a policy solution the Working Group suggests to overcome it. Some background information is also included. An important note, the Legislature may consider consolidating many of these recommendations into the Texas Advanced Nuclear Energy Authority, if they so choose.

7 Legislative Recommendations

1	**Texas Advanced Nuclear Energy Authority -** *A non-regulatory entity to coordinate Texas' strategic nuclear vision, implement ANR policy recommendations, and manage potential funds and oversight of state nuclear incentive programs.*
2	**Texas Nuclear Permitting Officer -** *A single point of contact for advanced nuclear reactor developers and associated businesses to navigate permitting.*
3	**Workforce Development Program for Community Colleges and Universities -** *Coordination plan between workforce, education, and industry to support a homegrown nuclear workforce in Texas capable of meeting ANR industry and Texas energy demand.*
4	**Texas Advanced Manufacturing Institute -** *Designed to develop and foster a nuclear ecosystem in Texas.*
5	**Texas Nuclear Public Outreach Program -** *A communications and public engagement plan to inform and educate Texans about the benefits of advanced nuclear power and reactor development.*
6	**Texas Nuclear Energy and Supply Chain Fund** - *A direct grant cost-sharing program to incentivize early development and siting, and support supply chain and manufacturing capacity readiness.*
7	**Texas Nuclear Energy Fund -** *An appropriation to a fund, modelled after the existing Texas Energy Fund, explicitly for advanced nuclear power to overcome the funding valley project developers face in Texas.*

Recommendation 1: Texas Advanced Nuclear Energy Authority

Establish a non-regulatory entity to coordinate Texas' strategic nuclear vision, implement ANR policy recommendations, and manage funds and oversight of state nuclear incentive programs.

Challenge: No single state entity exists to provide strategic leadership within the advanced nuclear reactor ecosystem. Lacking such guidance, Texas may be missing out on opportunities to enhance the state's nuclear power posture.

Recommendation: Create a Texas Advanced Nuclear Energy Authority (Authority) at an existing state agency. The Authority should have the ability to convene advisory councils comprised of members with industry, regulatory, and higher education/research and development interests' expertise that could continue to identify and study obstacles and opportunities and provide recommendations to future Legislatures to ensure Texas is the global leader in advance nuclear energy and technologies.

The Authority could also be authorized to administer any funds the Legislature may create to support advanced nuclear capital projects, supply chain development, and other initiatives.

Additionally, the Legislature may consider The Texas Advanced Nuclear Energy Authority as the appropriate home for many of the recommendations in this report.

Background: This new Authority would be well equipped to manage a project pipeline, attract new industry projects and partners to Texas, and signal state commitment to the development of this Industry. This Authority will ensure continued efforts of the Texas Advanced Nuclear Reactor Working Group and its 2024 recommendations, including those that are immediately actionable and opportunities to further study. Continued efforts of the Texas Advanced Nuclear Energy Authority will be focused on: supporting active ANR developers in Texas; the State's role in deploying and using advanced nuclear reactors; fostering homegrown development of advanced nuclear reactor technology; and supporting industrial capacity and supply chain in the state.

Recommendation 2: Texas Nuclear Permitting Officer

Designate a single point of contact for advanced nuclear reactor developers and associated businesses to navigate permitting.

Challenge: The regulatory environment for advanced nuclear energy is spread amongst multiple state and federal agencies. No single state-level point of contact exists who can help industry navigate the maze of obstacles that must be overcome to enhance the state's nuclear power posture.

Recommendation: Create a state Nuclear Permitting Officer who could be housed in the new Authority or an existing state agency. This role would facilitate smooth navigation of bureaucratic procedures and provide tailored assistance to companies seeking to build advanced nuclear reactor operations in the state. At a minimum, this role, and the subject matter expertise it brings would add value to the process by identifying the required permits and approvals per site and key personnel. Furthermore, this position could also be a point of contact to share information of Texas' economic incentive programs.

Background: Texas has an excellent regulatory system for getting major construction projects permitted safely and efficiently. Advanced nuclear reactor development poses unique and lengthy permitting and authorization challenges at the local, state, and federal levels, which translates into costs. For instance, Dow and X-Energy's Seadrift project demonstrating advance nuclear reactors deployed at a petrochemical site, had to navigate over 40 federal, state, and local entities.

A single point of contact would send a message that Texas is welcoming advance nuclear development and willing to support developers navigating the permitting process. Many of the companies seeking to build advanced nuclear reactors are based in other states, leaving them to navigate an unknown system without the necessary contacts to assist.

Recommendation 3: Workforce Development Program for Community Colleges and Universities

Coordinate workforce, education, and industry to support a homegrown nuclear workforce in Texas capable of meeting advanced nuclear industry and Texas energy demand.

Challenge: Workforce studies indicate a dramatic need for skilled labor in the areas of nuclear-grade welding, radiological control and monitoring, reactor operators, and nuclear instrumentation and control, in addition to non-nuclear power plant skills. Meeting demand will require renewed focus on nuclear power education for homegrown workforce development.

Recommendation: Build an advanced nuclear workforce development program to help address the homegrown skill and labor gaps. This program will be responsible for planning and budgeting around Texas' nuclear workforce demand-based expansion, developing a strategic roadmap for addressing labor supply gaps and talent retention, and developing and implementing programs to support:

- Technical and community college programs training of a skilled workforce of nuclear-grade welders, radiation control technologists, and reactor operators.
- Higher education research and development leadership through targeted funding for top-tier university hires and their research facilities.

Background: Nuclear power education at all levels in Texas could be improved to fulfill the construction and operations workforce demand of an advanced nuclear economy. Potential employees need more instruction in the basics of energy production and in nuclear technology specifically. Technical and community colleges will need to offer programs to provide training and certification for high-paying nuclear jobs. Universities will need to train more nuclear, electrical, chemical, civil, and environmental engineers to license, build, and operate new reactors.

Given proper coordination and funding, Texas has the nuclear workforce programming, relationships, research and development leadership, and experience needed to create and implement a roadmap to address the skill and labor gaps immediately. The State must make this a priority and provide the resources to scale up.

This Workforce Development Program could be administered by the Texas Workforce Commission with input from the Texas Higher Education Coordinating Board and the Texas Advanced Nuclear Energy Authority.

Recommendation 4: Texas Advanced Manufacturing Institute

Create an institute designed to develop and foster a nuclear ecosystem in Texas.

Challenge: Expanding Texas's nuclear power base will require specialized equipment and technologies which may not be readily available in the United States. This can limit the speed with which Texas is able to enhance the nuclear ecosystem within the state.

Recommendation: Establish an institute designed to develop and foster a nuclear network in Texas, which will demonstrate Texas' global leadership and commitment to this burgeoning industry and reclaim domestic jobs.

This Institute could bring together advanced nuclear developers, equipment manufacturers, and service providers to focus on the newest fabrication technologies that can ensure exact replication of parts at a reduced cost and allow the advance nuclear industry to grow quickly. Texas should become the premier hub for serving the nuclear industry by expanding the use and approval of these new fabricating technologies.

Background: As a leading provider of aerospace and energy sector equipment and services, companies in Texas are uniquely positioned to create a nuclear supply chain ecosystem that will benefit citizens across the globe. Texas should focus to build on these major manufacturing industries:

- The aerospace and defense
- The oil and gas equipment manufacturing
- Automotive manufacturing
- Semiconductor and electronics

Advanced manufacturing techniques are currently under review by the Nuclear Regulatory Commission and should be available to Texas industry to assist in the manufacture, fabrication, and installation of advanced nuclear reactors. Some of these technologies are already in use in the oil and gas industry, such as directed energy deposition additive manufacturing, powder bed additive manufacturing, electron beam welding, and powder metallurgy-hot isostatic pressing (PM-HIP).

Recommendation 5: Texas Nuclear Public Outreach Program

Implement a communications and public engagement plan to inform and educate Texans about the benefits of advanced nuclear power and reactor development.

Challenge: Continued support for advanced nuclear reactors will require educating the public on the safety, reliability, and benefits of nuclear technology.

Recommendation: By collaborating with state and local leaders and crafting effective messaging, this initiative will affirm that advanced nuclear technology offers safe, reliable, and affordable power for Texas, while also positioning Texas as a national leader in nuclear power deployment. These efforts will help to inform and produce targeted public outreach and workforce development programs.

Background: Recent national studies show widespread, bipartisan support for nuclear power across many demographics. Results also show a strong correlation between survey responders "feeling informed" on nuclear power and their support for nuclear power. Texas needs a coordinated outreach program to capture information on localized sentiments and support. The results can be used to drive coordinated education, outreach, and workforce development programs in strategic communities with a need for firm power supply growth.

Recommendation 6: Texas Nuclear Energy and Supply Chain Fund

Create a direct grant cost-sharing program to incentivize early development and siting and support supply chain and manufacturing capacity readiness.

Challenge: The unknown capital costs and risks for advanced nuclear development in the US deters the manufacturing basis to prospectively orientate business operations to the ANR equipment supply chain as well as deter capital from preconstruction investments.

Recommendation: A direct grant cost-sharing program can unlock private capital to deploy to advance nuclear projects and manufacturing capacity in Texas. The following appropriation programs, which could be administered by the Authority or other state agency, offer pathways for legislators to consider together or separately to maximize impact to the industry:

A. **Appropriation for early development and siting activities** that are low magnitude and high risk for nuclear power plant developers.
B. **Appropriation for supply chain and manufacturing capacity projects** to the capital cost of installing nuclear manufacturing equipment to support the advanced nuclear reactor supply chain. This program would apply to large and small manufacturing projects to reduce investor risks and capital costs while beginning to establish Texas as the global flagship for the advanced nuclear industrial base, bringing in high-wage jobs and economic opportunities.

Background: Siting efforts require investment so early in the project lifecycle that investments can be stifled given the risk of project cancellation. Investments in supply chain and manufacturing capacity are slow due to the magnitude of the initial investment needed to stand up facilities designed to meet sizable demand signals emerging from the advanced nuclear industry.

State support is key during these early industry development phases, including siting and infrastructure efforts required to justify a robust order book capable of deploying advanced nuclear projects. State support not only helps reduce uncertain early investor risk, it also improves a project's bankability and the capacity for incremental investments, reducing total project financing costs and ultimate impacts on ratepayers. These funds could be structured to enable draw down of federal funds for those interested in pursuing them.

Recommendation 7: Texas Nuclear Energy Fund

Create and appropriate funds to the Texas Nuclear Energy Fund explicitly for advanced nuclear power to overcome the funding valley project developers face in Texas.

Challenge: Capital costs for deploying advanced nuclear energy can be prohibitive.

Recommendation: The Legislature could create the Fund, modeled after the Texas Energy Fund, specifically for advanced nuclear reactor projects, adding generation capacity to the Texas grid by 2035.

Background: The Public Utility Commission of Texas (PUCT) was directed by the Texas Legislature through the Powering Texas Forward Act (Senate Bill 2627 88R), to administer the Texas Energy Fund programs. The TEF provides low-interest loans and grants to finance the construction, maintenance, modernization, and operation of electric facilities in Texas. This model could be used to help reduce capital costs with deploying advanced nuclear energy in Texas.

Conclusion

Texas is well-positioned to lead the country in the development of ANRs to provide safe, reliable energy for generations to come. While nuclear development will take years to come to fruition, Texas can act now to be the leader in the United States and set a path forward that welcomes industry participation, research, and development. The creation of an Authority dedicated to the strategic approach to expanding Texas' nuclear capacity is the likely first step. Additional steps of reducing bureaucratic barriers, reducing financial risks, and developing a workforce and supply chain are integral to Texas' future success in the nuclear industry.

TEXAS ADVANCED NUCLEAR REACTOR WORKING GROUP

ITEMS FOR FURTHER CONSIDERATION

Items for Further Consideration

While the 7 legislative recommendations discussed in this report provide options for the Legislature to consider in the immediate term, additional items will likely be worth considering as Texas continues to develop its ANR capabilities. Those items for future consideration are laid out next and should be considered as potential avenues of research for the Texas Advanced Nuclear Energy Authority in preparation for the 90th Texas Legislature.

Consideration 1: Nuclear Interconnection Costs

Interconnection costs are the cost of connecting a generation resource to a substation. Historically, generators did not pay to interconnect into the ERCOT grid. House Bill 1500 (88R) changed this paradigm with the inclusion of a "standard allowance," a threshold to protect ratepayers by shifting some high costs to generators. The Legislature directed the PUCT to create a structure for ensured financial discipline for power plants sited far away from interconnecting facilities. This direction encouraged generation facilities to site their facilities closer to demand centers by requiring them to pay the costs greater than their standard allowance. When the Commission adopted the rule, it was noted that the rule did not expressly exempt nuclear from having to pay for overages of the interconnection allowance.

While the PUCT may be able to utilize its authority in PURA 35.004(d-1)(3) to provide a good cause exception for nuclear facilities, a clear and limited clarification in PURA 35.004(d-2) could be helpful.

Consideration 2: Nuclear Energy Credits

Tradeable certificates (such as renewable energy certificates) are an established mechanism to compensate power generators for desirable attributes of the energy they produce. Texas already has an attractive market of voluntary buyers interested in nuclear energy credits. There is growing national demand for hourly tracking of energy attributes in the voluntary market, as well as potential regulatory interest for more granular tracking. Multiple Independent System Operators (ISOs) as well as third-party systems are being considered or have already implemented hourly tracking in other states. Industrial electricity consumers building new large load facilities and nuclear plant developers could be incented by a tangible, hourly-tracked credit trading program. This proven mechanism can connect Texas industry demand with prospective investors in new advanced nuclear power.

Consideration 3: Matching Program for Blended Power Purchase Agreements (PPAs)

PPAs are proven business-to-business financial devices used by developers and offtakers in which developers agree to build a certain capacity by a certain date and an offtaker agrees to buy the power at a certain rate. PPAs benefit developers by ensuring they have a committed customer for a generation project and benefit offtakers because they can plan their business around stable power capacity coming online at a specific time. Developers are typically responsible for most of the early project development and financing risk. PPAs are often an incentive for developers to unlock financing.

Texas' projected energy demand growth is increasing the appetite of large offtakers to commit early dollars to generation projects which will meet long-term business needs by accepting some of the early financing risk. This trend opens the door to new investment relationships between developers and offtakers earlier in a project lifecycle.

Developers and large load offtakers in Texas have expressed interest in advanced nuclear power projects in Texas that match load profiles for businesses such as chip manufacturers, data centers, AI, and industrial customers. Texas could consider incentivizing these project partnerships to reduce financial risk for future advanced nuclear development and improve the project financing calculus for additional outside investors.

Consideration 4: Provisional 'Certificates of Convenience and Necessity' (CCN) With Recovery of 'Construction Work In Progress' (CWIP) for Non-ERCOT Utilities

Healthy regulated utilities benefit customers, and stable and supportive regulatory environments are essential for long lead time and highly capital-intensive endeavors like advanced nuclear power development. Currently, Texas utility laws, regulatory processes, and ratemaking authorizations lack efficient cost-recovery mechanisms for non-ERCOT utilities to deploy long lead time resources like advanced nuclear reactors. A new resource approval process and regulatory cost recovery framework could support the unique, multi-year nature and financing needs of advanced nuclear projects in the non-ERCOT regions of Texas.

Recovery of construction costs enables regulated utilities to service debt and maintain crucial credit ratings, which not only drive the utility company's cost of capital but may affect investors' willingness to provide capital needed for utility investments. Two potential tools moving forward are “construction work in progress” (CWIP) costs and Provisional Certificates of Convenience and Necessity (CCNs).

Construction Work in Progress (CWIP)

CWIP refers to utility expenditures for projects in the process of construction and is eligible for Allowance for Funds Used During Construction (AFUDC). AFUDC is the existing regulatory accounting principle that allows for the capitalization of the cost to finance capital projects until they are placed in service.

Since nuclear reactors can take many years to build, CWIP statutes improve utility companies’ capacity to reduce the compounding financing costs and risk to investors and customers. Existing PUCT ratemaking rules allow for current CWIP recovery in very narrow circumstances not currently conducive for advanced nuclear projects.

Provisional Certificates of Convenience and Necessity (CCNs)

Existing statute and PUCT rules provide for regulatory approval of new power generation projects, including interconnection and other transmission infrastructure to support those projects, through CCN authorizations. Existing regulatory frameworks do not align with the multi-year development, pre-construction, and construction phases of nuclear reactor development. A provisional CCN framework could fix this and be customized for advanced nuclear projects. Provisional CCN authorizations granted by the PUCT should include clear milestones along a nuclear project’s development, specifically two distinct action periods to:

1. Evaluate project(s) for feasibility, permitting, siting, generation interconnection, regulatory approval, and other pre-construction activities and, perhaps, long-lead time equipment orders.
2. Advance project(s) through construction and operation, including any applicable network upgrades.

Consideration 5: Military Advanced Nuclear Incentive Program

The 2022 National Defense Authorization Act directs Critical Department of Defense (DoD) Missions to be powered 99.9% by reliable energy by 2030. DoD will be an early adopter of ANRs for reliable, carbon-free energy to meet this direction. The Defense Economic Adjustment Assistant Grant (DEAAG) Program, administered within the Office of the Governor by the Texas Military Preparedness Commission (TMPC), is an infrastructure and jobs grant program to assist defense communities. The TMPC has awarded over $129 million in 55 grants since the program's inception. The DEAAG can award up to $5 million per project per applicant, and loan up to $200 million via its revolving loan program. DEAAG's scoring criteria includes matching funds that can include local funding or in-kind contributions along with federal matching funds and initiatives.

The DEAAG is an efficient and effective program within the Office of the Governor designed to assist communities impacted, or could be impacted, by Base Closures or Realignment and is viewed as "base closure prevention program." With some modifications, DEAAG can further its mission by incentivizing advanced nuclear power on military bases in Texas. In addition to adding value to bases and communities, ANRs are the best electricity generation source that meets the DOD's reliability, clean energy, and resiliency goals.

Consideration 6: Demonstration Projects

Most potential consumers of nuclear power plants want to be the second or third customer, letting the first customer take the First-of-a-Kind (FOAK) risk. The State of Texas can incentivize companies to accept more risk by supporting several projects targeted at meeting state needs, such as: produced water cleanup in the Permian Basin, Permian Basin oil & gas development, power for a university campus, fortify the resiliency for state and national security assets, and desalination either on the coast or of brackish groundwater. Current demonstration projects are further described in Appendix G.

Consideration 7: Delegation of ANR Early Site Permitting to States, and Require the NRC to Accept the Use Of State Data and Advanced Tools to Reduce Costs and Time for Permits

The Nuclear Regulatory Commission likely will be overwhelmed by ANR siting applications by 2026–2028. If this the case, Texas should think differently on how Texas can control their own siting processes, data, and timelines for the timely consideration of early site permits.

Texas states agencies like the General Land Office, Texas Water Development Board, Texas Council on Environmental Quality, and the Department of State Health Services have many data sets that contain facts and figures that could be utilized by the NRC for siting. Duplicating these efforts is wasteful and where possible, state data should be accepted and required by the NRC.

Texas could urge Congress to amend federal law to allow states to request delegation authority for the processing of early sit permits through the development of a state program that is equal to or more stringent than the NRC. The NRC could approve the safety of ANR designs and let states approve the sites that could be utilized for these advanced reactor designs.

References

1. “5 Fast Facts About Nuclear Energy,” Energy.gov, accessed August 31, 2024, https://www.energy.gov/ne/articles/5-fast-facts-about-nuclear-energy
2. “Ultimate Fast Facts Guide to Nuclear Energy” (Department of Energy, 2019), 2, https://www.energy.gov/sites/default/files/2019/01/f58/Ultimate%20Fast%20Facts%20Guide-PRINT.pdf
3. Economic Impact of Texas Small Modular Reactor Industry Development, 2024–2055 (Initial Analysis). Prepared by the Bureau of Business Research , IC2 Institute, The University of Texas at Austin (October 2024).
4. “2023 Legislative Energy Trends,” NCSL Foundation for State Legislatures, March 18, 2024, https://www.ncsl.org/energy/2023-legislative-energy-trends
5. “Nuclear Output to Reach New Record by 2025, Says IEA,” World Nuclear News, January 24, 2024, https://world-nuclear-news.org/Articles/Nuclear-output-to-reach-new-record-by-2025,-says-I
6. Danielle Startsev, “REDACTED: ERCOT Recent Activity and Long-Term Outlook - Aurora Energy Research” (ERCOT Public Webinar, Web, June 18, 2024), https://go.auroraer.com/l/885013/2024-06-18/n7jnx/885013/1718739881zYV2UQzq/ERCOT_recent_activity_and_long_term_outlook.pdf
7. “Reactor Database Search,” World Nuclear Association, accessed September 1, 2024, https://world-nuclear.org/nuclear-reactor-database
8. Julie Kozeracki et al., “Pathways to Commercial Liftoff: Advanced Nuclear” (Department of Energy, March 2023), 8–13, https://liftoff.energy.gov/wp-content/uploads/2023/05/20230320-Liftoff-Advanced-Nuclear-vPUB-0329-Update.pdf
9. “Nuclear Explained - U.S. Nuclear Industry,” U.S. Energy Information Administration, August 24, 2023, https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php
10. “About NRC,” U.S. NRC, July 5, 2024, https://www.nrc.gov/about-nrc.html
11. “Texas Comptroller Energy Tour: Nuclear Overview,” Comptroller.Texas.Gov, accessed September 1, 2024, https://comptroller.texas.gov/economy/economic-data/energy/2023/nuclear.php
12. “Safety of Nuclear Power Reactors,” World Nuclear Association, August 23, 2024, https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors
13. “ADVANCE Act (Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy Act of 2024),” U.S. NRC, August 21, 2024, https://www.nrc.gov/about-nrc/governing-laws/advance-act.html
14. Patrick White, “Developing a New Regulatory Framework for Advanced Reactors: Update on Part 53,” ANS Nuclear Newswire, May 3, 2024, https://www.ans.org/news/article-6003/developing-a-new-regulatory-framework-for-advanced-reactors-update-on-part-53/
15. Stephen Burdick, John Wagner, and Jess Gehin, “Recommendations to Improve the Nuclear Regulatory Commission Reactor Licensing and Approval Process” (Idaho National Laboratory, April 2023), https://doi.org/10.2172/1974450
16. ADVANCE Act of 2024 Overview” (Nuclear Energy Institute, 2024).
17. Kozeracki et al., “Pathways to Commercial Liftoff: Advanced Nuclear,” 29–30.

APPENDIX

Appendix: Supplemental and Targeted Analyses

Appendix A:
Highlights From the Bureau of Business Research's Initial Analysis -Economic Impacts of Texas SMR Industry Development, 2024–2055

The Public Utility Commission's Texas Advanced Nuclear Reactor Working Group (Working Group) invited the Bureau of Business Research (BBR) of the IC^2 Institute at The University of Texas at Austin to conduct a study evaluating the economic impact of the creation of a Small Modular Reactor (SMR) industry in the State of Texas as well as an analysis of the economic impact of deploying SMRs in Texas.

Types of Analyses

1. **ERCOT Grid Modeling –** To estimate necessary cost reduction to make new nuclear generation capacity competitive under current market conditions and future trends.
2. **Estimated Economic Impact –** The total employment, gross domestic product, and disposable income that would be generated by building and deploying SMRs in Texas across 3 investment scenarios (Low, Medium, and High investment). Analysis uses the leading REMI tool for dynamic impact analysis and its E3 package for analyzing specific investments in the energy sector.
3. **Supply Chain Potential** – To characterize the relative potential of Texas businesses based on the number of businesses currently present in Texas industry sectors germane to SMR manufacture and deployment in the context of numbers nationally, comparing Texas to other states with arguably similar potential in the SMR industry. Analysis uses the North American Industry Classification System or NAICS.
4. **Business Surveys** – Findings from two BBR surveys: (1) a survey of Texas Economic Development Council professionals from across the state and (2) a separate survey of manufacturing businesses in Texas. The manufacturers' survey gauged business' interest in participating in the supply chain for SMRs being built in and deployed in and beyond Texas.
5. **Workforce** – A review and findings from an analysis of whether the Texas economy currently has, or can generate in the future, the workforce necessary to manufacture, construct, and operate SMRs in the state. This analysis also presents possible next steps in filling anticipated workforce gaps that might emerge.

Highlights and Key Findings

ERCOT Grid Modeling

SMR nuclear capacity is built when capital expenditures or CAPEX are at or below $2 million per megawatt (MW) and operating expenses or OPEX (fixed) are below $90,000 per megawatt-year.

Modeling results indicate that Houston and Dallas regions are load centers, likely to receive the most SMR capacity because of their industrial needs and growing populations. (SMR deployment may avoid having to meet growing electrical demand by transporting wind and solar power across Texas at peak hours.)

Estimated Economic Impact

We modeled three economic impact scenarios using a range of estimates of 300MW units built and deployed in Texas. Considering that there are no SMRs yet in operation, we acknowledge the wide range of estimates among nuclear energy experts of SMR units expected to be deployed in the next few decades. In addition, we assume SMRs will add to the state and national energy generation mix, not replace or displace existing legacy electrical energy generation.

Of the three scenarios we model (Low, Medium, and High investment), the Medium assumes 37 300MW units built and deployed just in Texas, and 771 built in Texas and deployed across the U.S. over 26 years by 2055, representing 242 gigawatts (GW) of SMR generation in Texas and the U.S. This scenario (a mid-range number of units built and deployed, using mid-range CAPEX and OPEX estimates and a moderate learning rate) results in significant economic impacts. On average, over the next 26 years:

- An annual average of 148,000 people employed directly and indirectly by the new SMR industry (construction, operations, manufacturing).
- $50.6 billion in new economic output in Texas.
- $27.3 billion in income to Texas workers.

Supply Chain Potential in Texas

By categorizing NAICS codes into segments and subsegments, we identify existing industries with the potential to participate in the SMR supply chain in Texas, and we highlight areas of weakness at the state level. The analysis is based on business count location quotients (LQs) for 10 SMR segments and approximately 30 subsegments. Texas is strong compared to the nation across the SMR supply chain, yet there are other states that are also competitive with Texas in their ability to support an advanced nuclear energy plant supply chain.

Business Survey

Approximately 35% of participants in our survey expressed interest in participating in an SMR supply chain. Based on this survey, industrial manufacturers are more likely to participate in certain segments and subsegments of the industry (e.g., balance of plant, inputs, and support services), though incentives are necessary to realize participation of these and other industry segments. Optimistically, about half of businesses are interested in using SMR power, including from the grid or private ownership.

Texas Economic Development Council Survey

More than 90 economic development officials with the Texas Economic Development Council (TEDC) responded to our survey with approximately 80 having experience in the past five years with siting or expansion of industrial plants and facilities. We received responses from city, county, and economic development entities in all 12 regions of Texas (Comptroller's official regions).

Electric power capacity is the single most important factor currently impacting (expansion or siting of) new industrial projects in their areas with "water supply," "access to talent," "access to development ready sites," and "taxes and incentives" next in priority.

Officials rated the importance of the following characteristics of energy in this order:

- Certainty of electricity being available when facility begins operation
- 24/7 electricity without interruptions
- Amount of time before electricity would be available at the facility
- Cost of electricity
- Decarbonized source (green) of electricity

Numerous specific examples were citied of instances in their areas in which insufficient energy/electricity availability had negatively affected a siting decision.

Workforce Analysis

We utilized multiple data sources and methodologies in reviewing a range of workforce issues. The analysis collected information and data through interviews about current nuclear workforce challenges, anticipated operational and construction employment from a 300 MW SMR, and forecasts of operational and construction/manufacturing employment from the REMI economic impact model, using the medium scenario of 37 SMRs deployed in Texas and 771 manufactured in Texas. Our analysis concluded that the state should not have any major issues supplying an operational workforce. Initial employment from operations occurs in 2033 with approximately 1,000 workers, ramps up slowly, and peaks in 2055 at approximately 46,000 workers. Manufacturing and construction employment would begin in 2030 with more than 11,000 employees. The ramp-up is much faster and peaks in 2046 at approximately 250,000 workers. The major uncertainty and potential workforce challenge appears to be with a number of production-oriented occupations for manufacturing SMRs. We suggest a future monitoring function regarding workforce issues. A monitoring unit could perform a series of tasks to ensure adequately trained operational and manufacturing employees would be available if, and when, SMRs move forward.

Full Report

Despite the uncertainties inherent in estimating the economic impacts of an SMR industry that is in its earliest stages, the research team has used the most reliable modeling and other methodological approaches available to present policymakers, local leaders, and industry experts with up-to-date information about the potential economic benefits that may accrue to the state from manufacturing and deploying SMRs in Texas.

See the full report on the PUCT website.

Appendix B: ClearPath Model on Federal & State Tax Incentives

ClearPath developed and used a net present value (NPV) model to analyze various policy levers' impact on the profitability of hypothetical advanced nuclear projects in Texas to identify the suite of policies that have the greatest impact on project economics and are the most efficient for the given amount of public funding. Specifically, the ClearPath's forthcoming report evaluated state-level tax credits, capital-cost share programs, blended Power Purchase Agreements (PPAs), and the Texas Energy Funds (TEF) grant and loan provisions. Findings from the ClearPath draft report are below, and a full report will be forthcoming.

The modeling of existing federal tax credit incentives concluded that additional policy levers will be needed for the commercial liftoff of advanced nuclear. This is supported by leading macro energy models showing limited deployment of new nuclear even with recent federal tax credits and other incentives.[1] Notably, a recent case study of small modular reactors in ERCOT found that nuclear costs must decrease significantly for SMRs to be economically viable in ERCOT.[2] ClearPath's analysis found the federal investment tax credit (ITC) is preferable for projects, compared to the production tax credit (PTC) when overnight capital costs (OCC) are $3,000 kW and greater, see Figure B1. The analysis defines the baseline as a project claiming the highest value federal ITC with a monetization haircut of 10% to reflect a best-case scenario for a nuclear project deploying in Texas.[3]

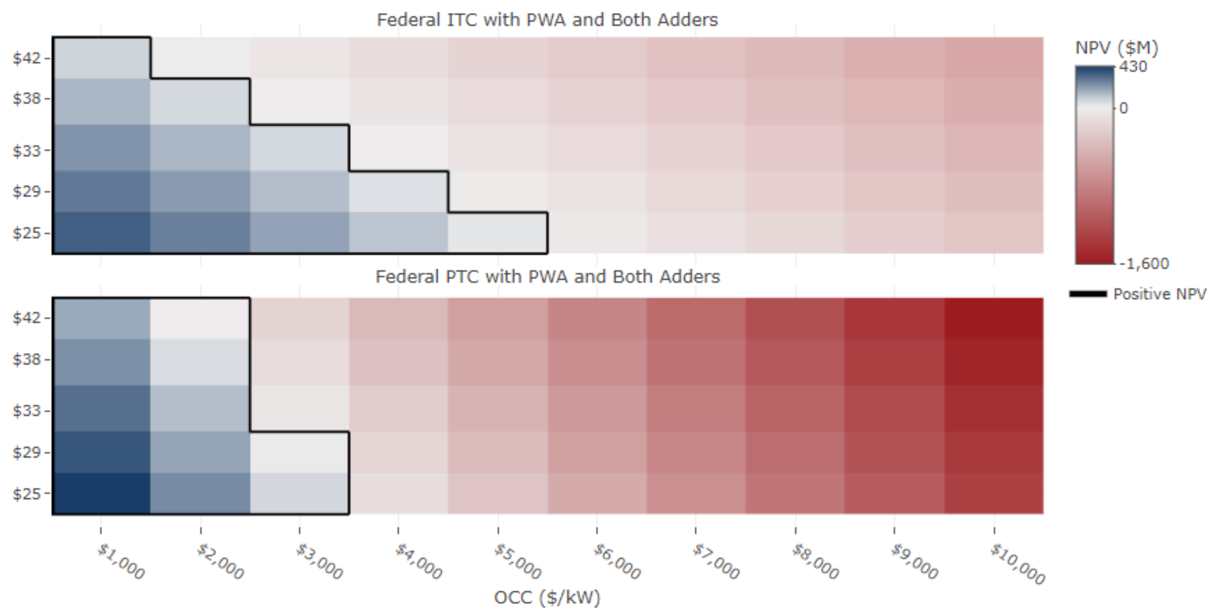


Figure B1. The matrix of nuclear OCC and operations & maintenance (O&M) costs results in a positive NPV in millions of dollars. A haircut of 10% is applied to both the ITC and PTC. Values with a positive NPV are shaded blue and encompassed by black borders. Negative NPV values are colored red. Note that the legends for each graph may have different scales.

[1] https://www.nrel.gov/docs/fy24osti/87724.pdf; https://rhg.com/research/taking-stock-2024/; https://zenodo.org/records/13345138

[2] https://www.frontiersin.org/journals/nuclear-engineering/articles/10.3389/fnuen.2024.1379414/full

[3] The Inflation Reduction Act tech-neutral tax credit structure provides incentives and bonuses that increase the tax credit value when provisions are met. These include meeting Prevailing Wage and Apprenticeship requirements, Domestic Content thresholds for project components being produced in the U.S., and locating the project in an Energy Community. For more information see https://bipartisanpolicy.org/download/?file=/wp-content/uploads/2022/08/Energy-IRA-Brief_R04-9.26.22.pdf

Regarding state-level tax credits, the ClearPath's forthcoming report recommends adapting the existing Franchise Tax Credit for Clean Energy Projects (FTC) to include nuclear. This was the most cost-efficient state tax policy to advance nuclear's economic viability, see Figure B2. The assessment of a state-level ITC, state-level PTC, and FTC determined that the FTC improves the project's NPV most tax-efficiently. The state PTC is advantageous at lower nuclear costs but results in the most foregone taxes (i.e., tax revenue not collected by the state) by an order of magnitude compared with an FTC. The ITC generated the greatest improvements in NPV; however, the ITC foregoes more taxes than the FTC and may have implementation challenges, such as tax liability constraints for monetization.

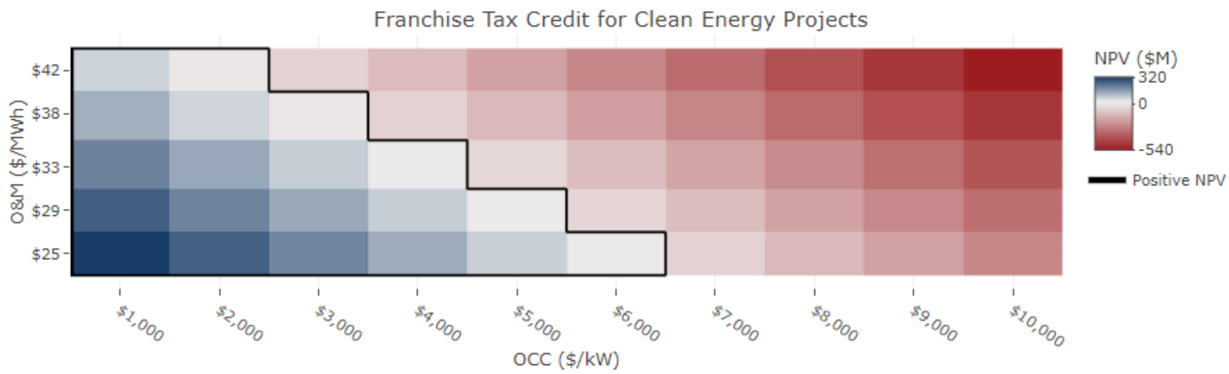


Figure B2. The results for project NPV when a state FTC and federal ITC are applied to a range of OCC and O&M costs. Values with a positive NPV are shaded blue and encompassed by black borders. Negative NPV values are colored red.

This analysis determined that grants targeting early-in-time capital outlays are advantageous for reducing high-risk capital costs and eliminating financing costs. Pre-construction activities – site feasibility studies including meteorology and geotechnical data; Front-End Engineering Design (FEED) or pre-FEED studies; and Nuclear Regulatory Commission licensing documents – are exploratory and difficult to finance due to perceived risk. A capital cost-share program that provides grants for these activities in a milestone-based manner will have an outsized impact on a project's NPV for the relatively small share of capital expense they represent, accelerate the development of new projects by derisking early-stage activities, and can be designed to be prudently managed, see Figure B3. The state can also explore providing grants for direct/material costs and indirect/labor costs these significantly improve project economics, and providing grants at different milestones of the development process also builds in cost prudency for Texas, as projects that adhere to project timelines and achieve deliverables will receive high-impact policy support.

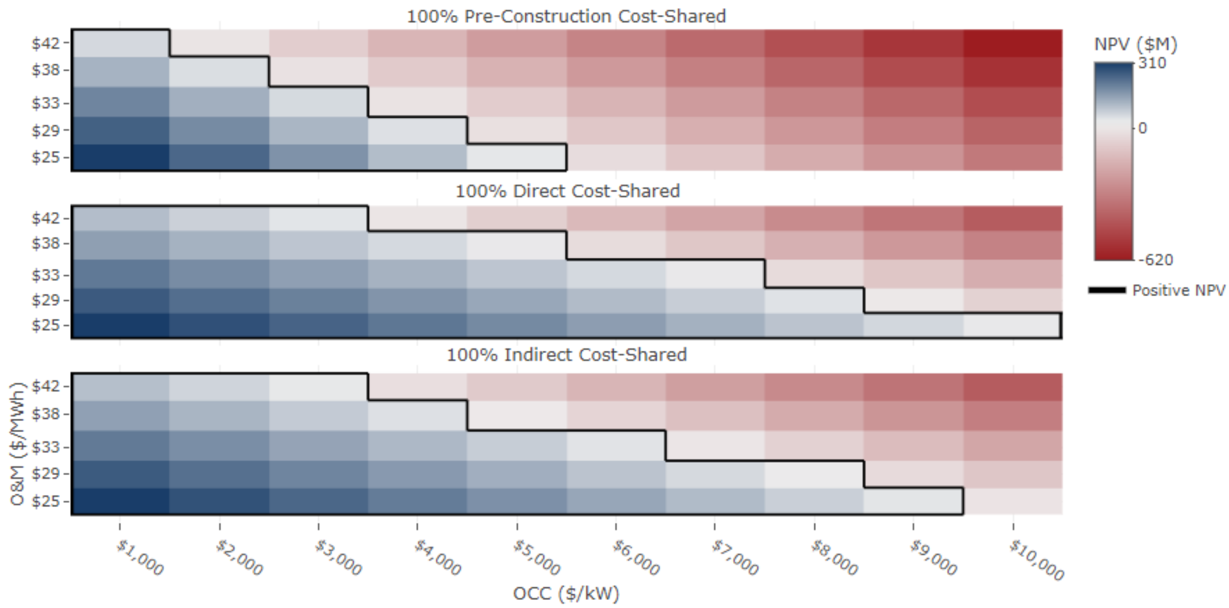


Figure B3. The results for project NPV when capital cost share amounts are applied to OCC. Values with a positive NPV are shaded blue and encompassed by black borders. Negative NPV values are colored red.

ClearPath's forthcoming report recommends that Texas evaluate blended PPAs as a possible alternative to expanding the TEF programs. The TEF Grants and Loans program has benefits similar to those of the PPA agreement – reduced financing costs that improve bankability and out-of-market compensation for generators that enhance economic viability – but notable differences exist. The TEF Grant discounting and awarding of the funds occurs after the performance year, so project bidding and operational decisions cannot be optimized as they can be under a PPA arrangement where operational decisions can be based on established contract terms and market dynamics. Further, the TEF Grant program does not provide opportunities for leveraging private-market actors to the degree that different PPA arrangements can. Texas can explore PPA arrangements that match private off-taker terms or provide premiums on private off-taker amounts to catalyze private sector funds and spur deployment at the margins. The analysis found higher PPA premium prices at low to moderate output shares more efficiently improve project economics than PPAs with lower premiums covering a more significant share of project output. Figure B4 illustrates how PPAs and the TEF can perform comparably well for improving nuclear project economics. However, the TEF Grant programs were significantly cheaper and more efficient per return on invested capital (ROIC) than PPAs.

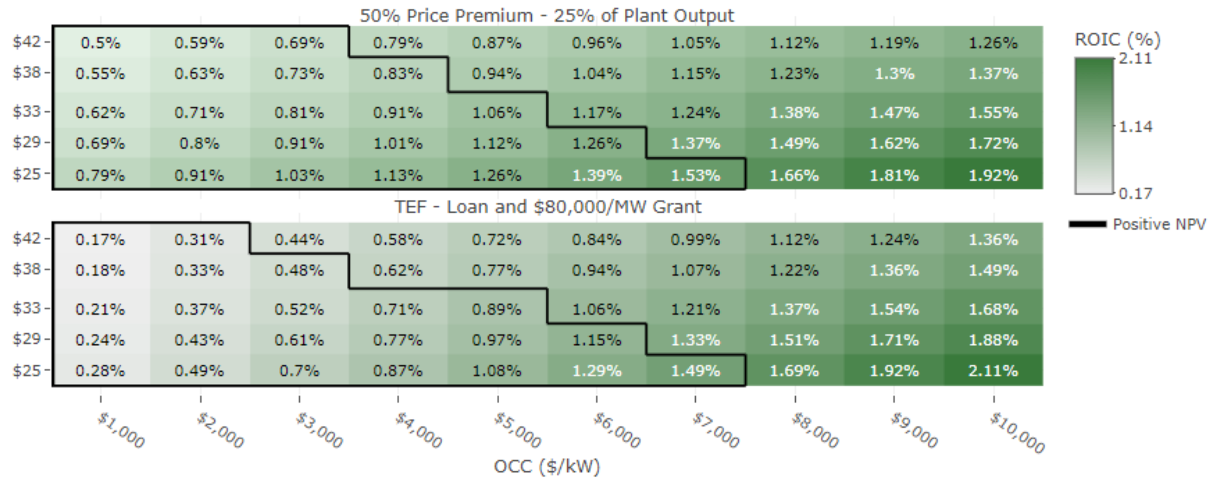


Figure B4. The ROIC results for a PPA with a 50% premium over average market prices covering 25% of output versus the TEF Loan and $80,000/MW Grant Programs. Darker green values reflect a higher ROIC, indicating greater improvement in project NPV, while light green represents lower ROIC values The black borders encompass the combination of nuclear costs that achieve a positive NPV in the analysis. Text colors adjusted to improve readability.

ClearPath evaluated the combination of the recommended policies – FTC, pre-construction Capital Cost Shares (CCS), and blended PPAs – and found the project's economic viability is greater than under any one policy. Figure B5 illustrates how the combinations of the FTC, CCS, and blended PPA impact nuclear economics. For the CCS, the ClearPath’s draft report highlights a 100% CCS for pre-construction costs due to their outsized impact on NPV and the milestone-based approach with 75% preconstruction, 50% direct costs, and 25% indirect costs. The results show the benefits of implementing the suite of recommendations, rather than individually, to project economics. The cost combinations made economically viable are greater, and the ROIC values are higher when policies are combined than individually.

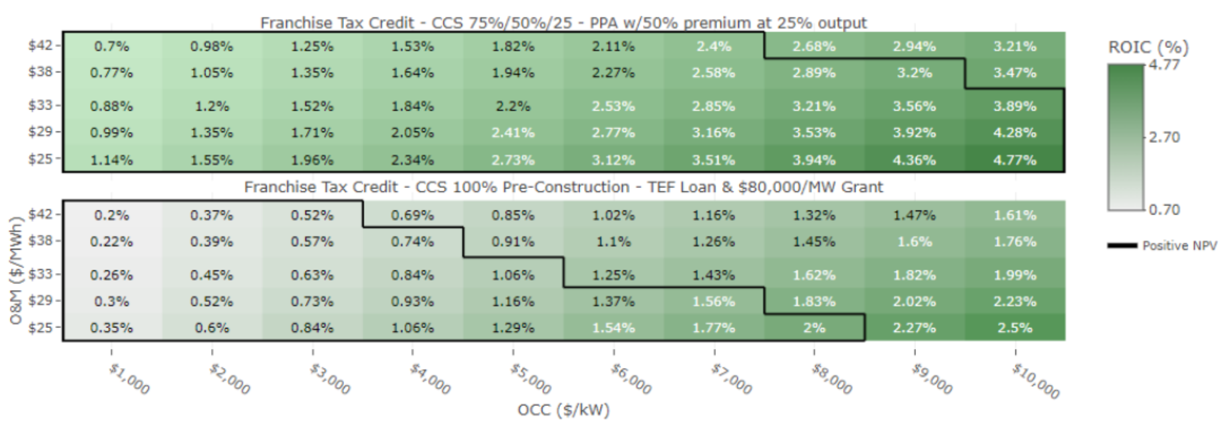


Figure B5. The ROIC results for the recommended policies. Darker green values reflect a higher ROIC, indicating greater improvement in project NPV relative to the baseline, while light green represents lower ROIC values The black borders encompass the combination of nuclear costs that achieve a positive NPV in the analysis. Text colors adjusted to improve readability.

Implementing all three policies does result in higher total policy costs, excluding foregone tax revenues (see Figure B6). However, this combination of policies can make higher-cost projects economical, which may be necessary for early deployment. Texas should consider tailoring policies to project deployment numbers or technology costs to right-size public support for nuclear deployment.

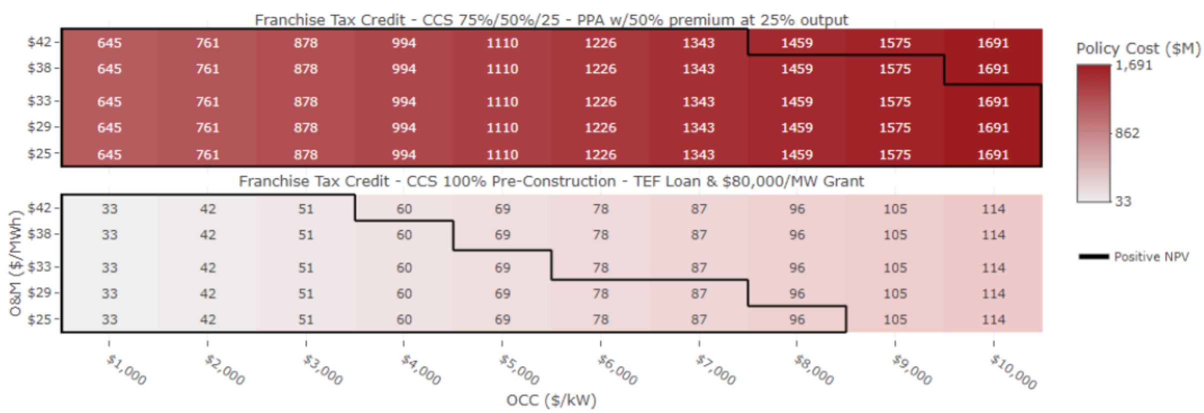


Figure B6. The policy cost from CCS and PPAs. This measure excludes foregone taxes generated by the FTC. Darker red values reflect higher policy costs, while lighter red represents lower policy costs. The black borders encompass the nuclear cost combinations that achieve a positive NPV in the analysis. Text colors adjusted to improve readability.

Finally, the ClearPath investigated the impact of these recommended policies on future ERCOT consumers in the form of monthly or per kiloWatt hour (kWh) charges on ratepayer bills. The analysis uses historical data on the number of customers (i.e. meters) and retail sales of electricity in Texas to project future growth in these figures.[4] The results are projected over the assumed 60-year lifetime of a plan to estimate how much these policies would cost as a monthly fixed charge or a per kWh charge spread across all customers and usage during this time period. This simplistic estimation of the recommended policy lever's affordability demonstrates that impactful policy support for advanced nuclear will not necessarily burden Texas' future ratepayers, see Table B1.

[4] https://www.eia.gov/electricity/data.php#sales

Recommended Policies	Nuclear Project Costs	Total Cost of Non-Tax Policies ($M)	Monthly Fixed Charge	Total Cost per Consumer of Monthly Charge Policy	$ per kWh charge	Total Cost per Consumer of kWh Charge Policy
Franchise Tax Credit - CCS 75%/50%/25% - PPA w/50% premium at 25% output	Lowest OCC and O&M	$645	$0.34	$244	$0.00001	$20
	Highest OCC and O&M	$1,691	$0.89	$639	$0.00002	$52
Franchise Tax Credit - 100% Preconstruction CCS - TEF Loan & $80,000/MW Grant	Lowest OCC and O&M	$41	$0.02	$15	$0.0000005	$1
	Highest OCC and O&M	$130	$0.07	$49	$0.0000016	$14

Table B1. The estimated cost per ratepayer for implementing each policy lever. ClearPath model fixed monthly charges and per kWh charges based on ClearPath's projections of total meters in Texas and total consumption across a 60-year period.

Appendix C: OR-SAGE Screening Analysis of 61 Texas Sites

Through the work of the Texas Advanced Nuclear Reactor Working Group, the Texas PUCT is interested in reducing the risk of nuclear deployment decisions by creating a portfolio of deployment locations that meet site selection requirements for the future deployment of new nuclear technologies.

This work summarizes siting evaluation assistance provided to the Working Group for suitability of advanced nuclear technologies to meet siting criteria from the Nuclear Regulatory Commission (NRC) and associated guidance documents including the Electric Power Research Institute (EPRI) siting guide and other proprietary datasets. This tool uses a wide array of GIS data sources to identify candidate areas for advanced nuclear energy technologies. The Oak Ridge-Siting Analysis for power Generation Expansion (OR-SAGE) tool utilizes the NRC siting criteria in its methodology, so it provides a quick easy screen for sites across the state.

The unique OR-SAGE tool and existing data is applied to support the desire to evaluate potential brownfield sites. Applying these parameters to each Texas site resulted in two analyses for each site including the desired look at a small, advanced technology such as the XE-100 reactor[5] and a comparison for a large liquid metal cooled reactor (LWR). Each of the 61 sites also has a 9-page data summary available on request from the PUC.

In May 2024, The Oak Ridge National Laboratory (ONRL) staff evaluated 21 existing (15) and recently retired (6)[6] coal sites in Texas based on Texas based on a recent DOE coal-to-nuclear study.[7] Of these 21, 20 appear to be amendable to consideration for ANR siting.

In August 2024, the Working Group sent 40 additional strategically chosen sites for evaluation. Factors such as ports, State-owned lands, high-growth areas, and industrial complexes were considered. Most of the 40 sites evaluated should be amenable to consideration for ANR siting.

For further details see the May 2024 and August 2024 full reports on the PUCT website.

---

[5] XE-100 is an example of a small, advanced reactor technology. The XE-100 reactor is an 80 Mwe pebble-bed, high-temperature, gas-cooled reactor (HTGR) designed by X-Energy. There are numerous small, advanced reactor designs in development. ORNL is not endorsing any specific technology.

[6] Big Brown, Gibbons Creek, Monticello, Oklaunion, Sandow 4, and Sandow 5.

[7] J. Hanson, et al., Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, INL/RPT-22-67964, Rev. 1, September 13, 2022.

Appendix D: Texas' Existing Nuclear Assets

Texas is already a nuclear state, with:

- **Nuclear power**. Texas is home to two nuclear power plants that generate over 5 GWs of electricity or 10% of energy on the ERCOT grid: two units at Comanche Peak Nuclear Power Plant and two units at the South Texas Project that have demonstrated exemplary performance, resilience during extreme weather, and safety. And further, the Pantex Plant near Amarillo, TX, is the primary U.S. nuclear facility that maintains the safety, security and reliability of the U.S. nuclear stockpile.
- **Higher education.** Texas is home to two world-renowned nuclear degree and research programs and the newest, privately funded research reactor seeking federal approval. Many other colleges and universities in Texas have top-tier programs tailored towards specific attributes of the safety, security and operations of nuclear plants. Nuclear medicine is a dominant tool in every hospital across the state and Texas medical research institutions are world renowned for their innovation.
- **Uranium mining.** Uranium mining for the nuclear fuel supply chain is growing across the state. Texas has one of the most suitable uranium deposits for extraction in the U.S., and is a preferred source of North American yellowcake. Texas' uranium reserves account for 8% of known U.S. uranium.
- **Regulatory oversight.** Texas has three state agencies, and a low-level radioactive disposal site (through an interstate compact) that currently regulate radioactive materials.

Texas currently is home to numerous nuclear assets and supply chain companies.
The State of Texas is home to two nuclear power plants that generate over 5 GW of electricity: two units at Comanche Peak Nuclear Power Plant and two units at the South Texas Project. In addition, Texas universities operate three research reactors for student training, academic research, and nuclear services, with a fourth reactor planned for operation soon. Uranium mining for the nuclear fuel supply chain is growing across the state. Nuclear medicine is a dominant tool in every hospital across the state. And further, the Pantex Plant near Amarillo, TX, is the primary United States nuclear facility that maintains the safety, security and reliability of the U.S. nuclear stockpile.

Nuclear Power Generation

Comanche Peak: Vistra's Comanche Peak Nuclear Power Plant in Glen Rose, TX, produces 2,400 MWs of emission-free nuclear power rain or shine—that's enough to power around 1.2 million homes. The two nuclear units are Boiling Water Reactors (BWRs) with an impeccable safety record.

The facility began commercial operations in 1990 and the site has over 600 employees with more than 200 permanent contractors.[8] In addition, the periodic refueling outages, which routinely occur four times over a three-year period, require supplemental workers and bring in anywhere from 800–1,200 skilled technicians from across the country. In short, the plant employs well over 1,000 Texans and provides electricity to millions of Texas citizens and businesses.

The Institute of Nuclear Power Operations (INPO) recognizes Comanche Peak at an exemplary performance level—a distinction given only to the safest and highest performing nuclear plants in the U.S. As the largest taxpayer in Somervell County, TX, the plant pays more than $30 million a year in state and local taxes and donates thousands of dollars to local community organizations. And in July 2024, Vistra received approval from the U.S. Nuclear Regulatory Commission (NRC) to extend the operation of the Comanche Peak plant (both units) through 2053.

[8] When considering staffing, it is important to know that advance nuclear reactor development requires fewer employees than prior designs.

South Texas Project: South Texas Project Electric Generating Station (STP) is a 2,645-MWs, dual-unit nuclear plant located about 90 miles southwest of Houston. The STP site is located on a 12,220-acre site in Matagorda County, between Bay City, TX, and Palacios, TX. The facility is managed by the STP Nuclear Operating Company and employs approximately 1,200 full-time personnel.

STP is currently owned 44% by Constellation Energy, one of the largest nuclear operators in the country, CPS Energy in San Antonio currently owns 40% and Austin Energy owns 16%.

STP has made the case for nuclear energy's resilience and reliability through successful storm responses. Both STP units remained online, safely operating at 100% power through Hurricane Harvey in 2017 and Hurricane Beryl in 2024. Storm crews were sequestered onsite, maintaining safe operations to provide Texans with power needed throughout the storm.

The facility has been honored as one of America's Safest Companies by *EHS Today*—the nation's first nuclear facility to be recognized in the history of the award. STP maintains a strong safety-focused culture that prioritizes personal, nuclear, radiological and environmental safety.

Texas Uranium Mining

Texas has one of the most suitable uranium deposits for extraction in the U.S. In Texas, most surveyed deposits are situated within the coastal plain and are sandstone-hosted. Texas' reserves account for 8% of known U.S. uranium. There is primarily only one type of uranium mining in Texas, *in situ*. In situ mining is the process of pushing fluid into the ground to dissolve minerals. Once the fluid is pumped back to the surface it is processed, and uranium is extracted and then concentrated into a usable form.

Many of the uranium deposits in Texas are situated close to the Eagle Ford shale basin. As in the Permian, some oil and gas extraction companies are evaluating whether to capture uranium as well in their processes as demand grows.

Higher Education

Texas is home to two world-renowned nuclear degree and research programs at the University of Texas at Austin and Texas A&M University in College Station. Both universities have been on the leading edge of nuclear research for decades and are well positioned to be leaders as the world looks toward nuclear power again. Both universities have an operating research reactor that is the cornerstone of their programs. Texas is also home to the newest, privately funded research reactor moving apace to get NRC approval at Abilene Christian University.

The University of Texas at Austin's Research Reactor

TEXAS The University of Texas at Austin

Nuclear Engineering was first offered at The University of Texas at Austin (UT Austin) in 1960, initially in the Engineering Science department and later moving to the Mechanical Engineering Department. Since 1963, the TRIGA (Testing, Research, Isotopes, General Atomics) nuclear reactor at UT Austin has been operating and providing a research environment at the university. Today, the reactor is one of the top three most active university reactors, allowing students to operate the reactor as part of a class, training operators, providing neutrons for research experiments, and producing medical isotopes for cancer trials.

The Nuclear Engineering program at UT Austin specializes in cutting edge, collaborative research across nuclear power, nuclear security, and medical uses of radiation. It graduates approximately 20 undergraduate students and 10 graduate/doctoral students per year. Graduates work for reactor design companies, owner/operators, national labs, universities, and government agencies.

Texas A&M University's Research Reactor

TEXAS A&M UNIVERSITY®

The Department of Nuclear Engineering at Texas A&M University is the largest program (by student population) in the United States. Established in 1957, the department has grown into a world-renowned program with annual research expenditures exceeding $12 million. As of Fall 2023, enrollment included 293 undergraduate, 46 Master's, and 80 Doctoral students.
The department maintains and operates some of the most state-of-the-art and best equipped research facilities in the country, including:

- Two nuclear reactors (1 MW and 5 W) for teaching, service, and research
- An extensive accelerator laboratory with 5 beamlines
- Multiple thermal hydraulic power and safety laboratories

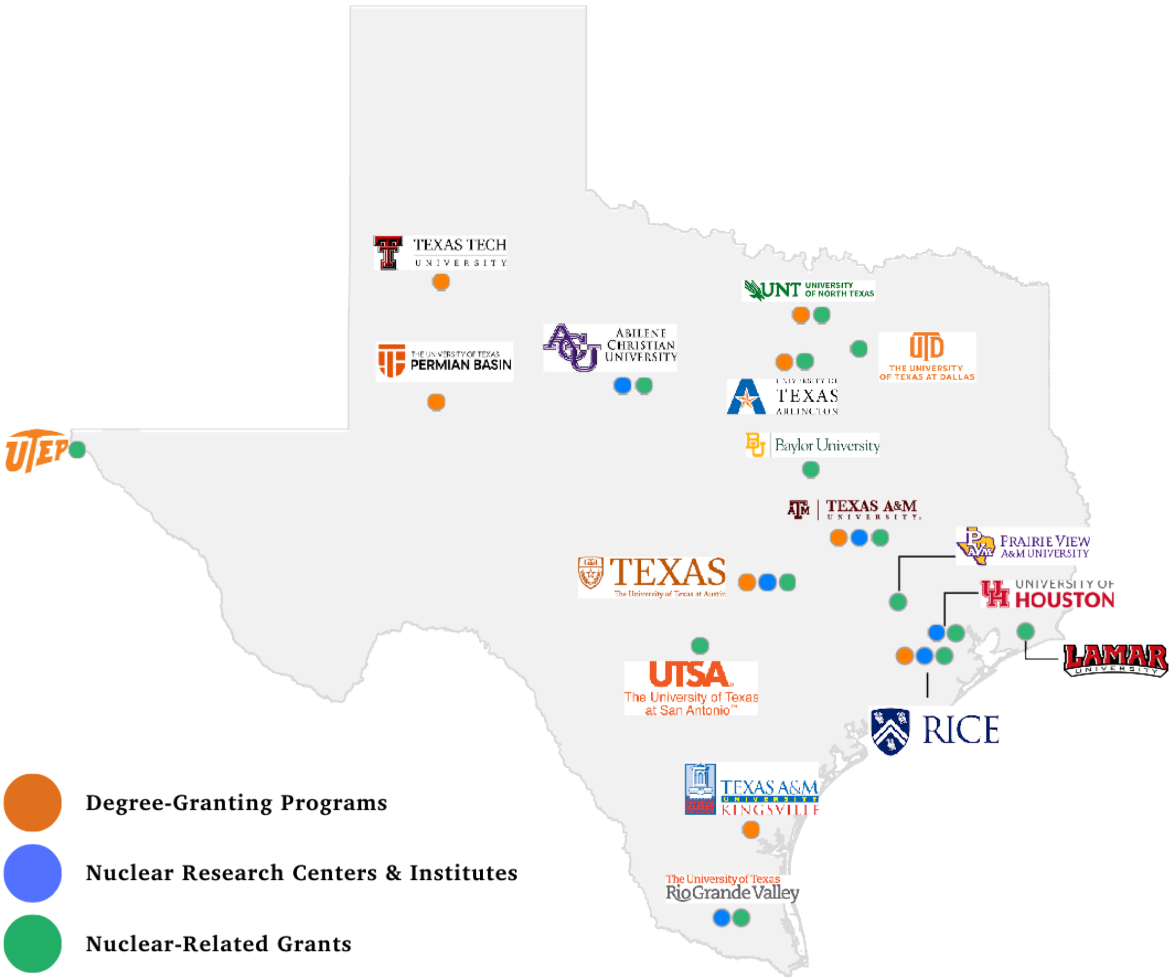
- Radiation Detection and Measurement Laboratory
- The Fuel Cycle and Materials Laboratory (advanced fuel and waste materials)
- Nuclear Power Plant Simulator for training
- Computational facilities

In addition to the major programs just summarized, many other colleges and universities in Texas have top-tier programs that are tailored towards specific attributes of the safety, security and operations of nuclear plants. Wharton County Junior College offers a nuclear/nuclear power technology/technician degree. Graduates most often find work at the STP nuclear plant due to their close proximity and coordination, a model for other programs to replicate.

Texas university systems have been leaders in granting nuclear degrees and receiving research grants to support the needs of the nuclear industry for decades. Both public and private universities and colleges participate in this educational effort as well as numerous community and technical colleges. As we embark on this new generation of assets, universities and community colleges must be prepared to address the immediate needs of industry.

Texas has eight public universities that offer degrees of varying levels in all regions of the state. In addition, ten nuclear research centers are currently housed in Texas universities which are dedicated to cutting edge nuclear and energy research. Wharton County Junior College's nuclear certification lab is a primary source of operators and has gained major recognition. Finally, grants received by Texas entities include the areas of nuclear cybersecurity, small modular reactor research, accident tolerant fuels heavy ion physics, and NuSTEAM – Nuclear Science in Texas to Enhance and Advance Minorities. These programs are robust and building blocks for more programs and participation in the future.

Figure. University Programs Throughout Texas.



Supply Chain Companies

Texas has relatively few companies that are currently part of the nuclear supply chain, primarily because most existing nuclear supply chain companies are located in closer proximity to the majority of the existing nuclear plants in the Mid-Atlantic States and Upper Midwest. However, thousands of companies offer supply chain opportunities for Texas. For instance, Wyman Gordon a Houston Based Berkshire Hathaway company, , that is currently a supplier to the United States Navy's nuclear programs as well as a parts provider to many oil and gas and aerospace companies. Its massive facilities would be ideal locations to place new forges or hot isostatic press furnaces.

While Texas is home to only 4 nuclear certified companies (N-Stamp), the supply chain in Texas can easily pivot to provide for this new industry given Texas' dominance in oil and gas, industrial and refining industries. To that end, Texas is home to over 600 companies that supply presser vessels to refineries and industrial facilities. Much of the quality assurance associated with the "U-Stamp" for pressure vessels can be translated to the N-Stamp for nuclear as this industry grows.

The Working Group asked Bureau of Business Research at the University of Texas at Austin (BRR) to evaluate the opportunities for businesses in Texas to be included in the future supply chain for commercial nuclear components. BBR analyzed the industry classification codes (NAICS codes) with nuclear plant development, construction and operations, and then cross referenced these codes with the companies that utilize those codes in Texas. Further details can be found in Appendix A and in the BBR's full report.

EPC Contractors

Texas is home to many of the largest Engineering, Procurement, and Construction (EPC) firms in the world. From Zachry Industrial Group in San Antonio to Fluor and Jacobs in Dallas to the regional offices of Bechtel and many others. These firms manage the thousands of construction workers needed to build these large projects, the engineering teams to design, and the procurement professionals that stage the acquisition of parts and long lead time items. They are a crucial part of the supply chain in Texas and having so many operating here in Texas is a huge opportunity to build upon.

Regulatory Oversight

Texas has three state agencies, and a low-level radioactive disposal site (through an interstate compact), that currently regulate radioactive materials. These are:

- Texas Department of State Health Services (DSHS) & its Radiation Advisory Board (TRAB)
- Texas Commission on Environmental Quality (TCEQ)
- Railroad Commission of Texas (RRC)
- Texas Low-Level Radioactive Waste Disposal Compact Commission (TLLRWDCC)

Texas Department of State Health Services (DSHS) regulates and licenses possessing, receiving, using, handling, transferring, transporting, and storing radioactive material, including low-level radioactive waste and naturally occurring radioactive material (NORM). This does not include radioactive material received by a licensed by-product material or low-level radioactive waste disposal facility regulated by TCEQ. DSHS also registers radiation-producing equipment.

The Texas Radiation Advisory Board ("Board or TRAB") was established in 1961 and is governed by the Chapter 401 of the Texas Health and Safety Code and 25 Texas Administrative Code §289.202.[1]

The TRAB members are the state's advisors on all radiation issues. The board holds periodic meetings to review the rules, guides and programs of the agencies that regulate radiation. TRAB members (19 representing a swath of sectors that deal with the safe application of radiation, like medicine) participate in hearings by providing expert testimony. They make recommendations about various issues and provide those to the agencies, the Legislature and the Governor.

The TRAB develops and implements policies that provide the public with the opportunity to appear at public meetings and speak on any issue under the jurisdiction of the advisory board, which is part of the State Department of State Health Services.

Texas Commission on Environmental Quality (TCEQ) licenses low-level radioactive waste disposal (including legacy buried waste sites), by-product material disposal, alternative methods of disposal of radioactive material, radioactive waste storage and processing.

Texas Railroad Commission (RRC) regulates the disposal of oil and gas waste that contains NORM. The RRC works with the DSHS to ensure that radioactive materials and other radiation sources associated with oil and gas operations are properly regulated. The RRC also permits uranium exploration in Texas.

The Texas Low-Level Radioactive Waste Disposal Compact Commission, housed at TCEQ, oversees the activities conducted under the Texas Low-Level Radioactive Waste Disposal Compact (Texas Compact). The Texas Compact was established by the states pursuant to the Low-Level Radioactive Waste Policy Act.[2] The Texas Compact legislation was established in August of 1993 through the passage of Senate Bill 1206.

The parties to the Texas Compact, Texas and Vermont, recognize a responsibility for each state to seek to manage low-level radioactive waste generated within its boundaries. It is the policy of the party states to cooperate in the protection of the health, safety, and welfare of their citizens and the environment and to provide for and encourage the economic management and disposal of low-level radioactive waste.

Appendix E: Understanding and Developing ANRs

Advanced nuclear reactor (ANR) is a general term, much like the term automobile. It encompasses many designs, models, and technologies each with unique features and benefits, but all essentially solving the same foundational problem. Like an automobile is designed to get you from point A to point B, ANRs are designed to provide power and heat.

Compared to the conventional, utility-scale reactors currently powering our grid, ANRs have simpler designs with enhanced safety, efficiency, constructability, and end use versatility. They can:[9]

- Integrate with intermittent energy sources and provide load following;
- Replace retiring coal plants while maintaining local economies and jobs;
- Be scaled to support everything from large loads from towns and data centers to small, critical loads from hospitals and military bases; and
- Produce process heat and hydrogen to improve and decarbonize industrial operations making them well suited to power Texas' growing and diverse economy.

For Working Group purposes, ANRs are fission-based reactors falling into one of three categories: large reactors, small modular reactors, and microreactors. Size differences and portability largely drive their target market and end use.

Large reactors, 400–1400 MWe

Most conventional nuclear reactor units provide around 1000 megawatt electrical (MWe) of power and are almost exclusively Light Water Reactors (LWRs). In Texas, the average nuclear reactor has an installed capacity of about 1300 MWe.

Small modular reactors, 50–400 MWe

Small modular reactors (SMRs) have a smaller electric capacity rating than large reactors while still able to provide significant firm power to communities. ERCOT estimates one megawatt powers roughly 250 homes. One 300 MWe SMR would be enough to power over 60,000 homes or the equivalent to power entire cities like Pflugerville, Galveston, or Grapevine. Given their modular nature a dozen of the same SMRs deployed at a single plant could power the entire

[9] "Advanced Nuclear 101," Nuclear Energy Institute, accessed September 1, 2024, https://www.nei.org/advanced-nuclear-energy/advanced-nuclear-101

Austin Metro area.[10] SMRs are expected to be largely factory built, with modules shipped to a construction site and assembled there. This modularity will improve manufacturing quality which ultimately reduce costs. Also, many SMRs reactors use alternative fuels and coolants compared to LWRs, which enhances safety, reduces system complexity, and thus should reduce regulatory burden. No SMRs have been built in the U.S. to date, however there are a number operating or under construction abroad, mostly in China and Russia.[11]

Microreactors, less than 50 MWe

Microreactors are less than 50MWe, but more commonly are less than 20 MWe. They are highly portable, often transported as a single module from the manufacturing site to their destination. They can serve smaller energy district's needs and provide process heat and steam for industrial uses. Due to their portability, there is keen interest in using them in remote locations, on military bases, and even for mobile hospitals or in response to natural disasters. No microreactors have been deployed in the U.S. since the 1960s.[12]

The ANR Development Process

There are generally four phases of development for an ANR. In this section, we also summarize the various licensing and regulatory approvals that apply to ANR initiatives, discuss how to address barriers to bankability, and cover the available federal funding options to support ANR development.

Reactor Design - From the point a developer decides to build a reactor to the point they have an NRC approved design can be at least 5 years and some examples have taken 20 years. It requires a team of highly educated engineering and health physics experts to design a reactor capable of safely delivering firm, clean, and reliable energy. This should occur in a competitive commercial environment to ensure the best technology and team is deployed to market.

---

[10] "Fact Sheet - November 2021," ERCOT, November 2021, https://www.ercot.com/files/docs/2021/11/23/ERCOT%20Fact%20Sheet.pdf; "Census Bureau Tables," United States Census Bureau, accessed September 1, 2024, https://data.census.gov/table?q=pflugerville,%20Texas&g=160XX00US4857176

[11] Small Nuclear Power Reactors," World Nuclear Association, February 16, 2024, https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors

[12] David Shropshire, "Hold on! Did You Know That Microreactors Were Field Deployed over 60 Years Ago?," Idaho National Laboratory (blog), August 7, 2023, https://inl.gov/nuclear-energy/hold-on-did-you-know-that-microreactors-were-field-deployed-over-60-years-ago/

Site Selection - An operator must identify a location suitable for building a reactor. Suitability screening is based on many factors including health and safety; ecological considerations; transportation, transmission infrastructure, engineering costs, and socioeconomic factors.[13] This is a lengthy and costly process subject to significant federal and state-level regulatory and permitting approvals with special considerations given to the current condition or previous uses of the site.[14]

Construction - Site preparation, preconstruction, prefabrication, and manufacturing activities can begin before there is construction approval from the NRC. Construction on the actual reactor itself can begin when the NRC has issued the relevant construction permits or work authority approvals. This phase requires deep expertise, local capacity, and experience in manufacturing, building, construction, and project management. The closer the relevant heavy industry supply chain and manufacturing facilities are to the reactor location, the more integrated and efficient the building process will be. A skilled local workforce is also vital to ensuring the safe and timely operation of the completed reactor for its design life.

Commissioning - Commissioning involves the wide range of activities needed to bring the nuclear facility into service. All systems and equipment are verified for design compliance and to ensure they meet expected operational performance and safety metrics.

Licensing and Regulatory Approvals - There are essentially three key objectives for developers pursuing regulatory approval and licenses. They must obtain site approval for a planned reactor location, approve their reactor design, and get approval to begin construction of their design certification process at their approved site. The specific permits a reactor developer must seek can vary and depend upon the NRC processes and authorizations they are targeting. These are a few of the possible licensing and regulatory approval options:

- **Early Site Permit (ESP)** evaluate the safety, environmental, and emergency preparedness of applicants. Once an ESP is issued for a specific site, the owner can "bank" it for future construction for 10–20 years from the date of issuance. A state can pursue sites and then transfer an ESP to future reactor developers. While analysis of the safety, environmental, and emergency preparedness factors of the site is not optional,

---

[13] "Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide)" (Palo Alto, California: EPRI, November 21, 2022), 2–20, https://www.epri.com/research/products/000000003002023910

[14] Ibid, 4-1.

applicants are not required to get an ESP if they choose to instead pursue these approvals during the latter Combined License or Construction Permit/Operating License phase.

- **Design Certification (DC)** approves the reactor design itself. Once a reactor receives a DC, the vendor can build it themselves or sell the standardized design rights to other developers wanting to build a nuclear power plant. Developers are not required to pursue a formal DC.
- **Construction Permit (CP) and Operating License (OL)** are issued in a sequence, allowing a developer to build a reactor with a CP, and then finalize the OL prior to reactor startup. This is the traditional path to licensure and favored for FOAK projects currently under development. Adequate siting and design criteria must be addressed during the CP/OL processes, but a formal ESP or DC is not required.
- **Combined License (COL)** issues both a CP and OL. This pathway was created to support deployment of reactor designs that have been previously constructed and licensed, mitigating delays between construction and issuance of the OL. An ESP or DC may be used to streamline the COL process, but these are not required.
- **Limited Work Authority (LWA)** is special approval applicants can pursue in parallel with their COL or CP/OL application. LWA approval allows developers to begin certain kinds of soil and foundation work on areas reasonably known to be regulated by NRC safety and security obligations. The LWA allows developers to begin construction and project management activities sooner to reduce the total construction to commission timeline and costs to investors and ratepayers.[15]

Currently, the total licensing process, including the engineering required to achieve licensing approvals, can take anywhere from 6–10 years and cost reactor developers and investors between $500 million and $1 billion in upfront capital.

---

[15] Greg Oberson and Mike Spencer, "Construction Activities with the NRC," https://nric.inl.gov/wp-content/uploads/2021/07/NRIC-Reactor-Construction-Before-Issuance-of-CP-OL-final-2.pdf

Appendix F: Federal Funding Available for Building ANRs

Recognizing the chasm between regulatory uncertainty and early project financing for FOAK ANRs as well as the imminent need for clean, firm, reliable energy, some federal grants, loans, and tax credits are available to advanced nuclear technologies.

Federal resources and policies are key drivers to bringing new nuclear projects online. Programs like the Advanced Reactor Demonstration Program (ARDP) provided billions of federal dollars to support new nuclear power; the Dow-X-Energy reactor project in Seadrift, TX, for instance has received ARDP funding. The U.S. Department of Defense supports the development of a mobile microreactor through its Project Pele program. Additionally, over $2.7 billion in federal funding was made available to jumpstart domestic fuel production for many new reactor technologies.

The Generation III+ Small Modular Reactor Program has $900 million to support initial deployments of new water-based reactors by utilities and the DOE's Loan Program Office (LPO) has over $300 billion in loan authority available through its Energy Infrastructure Reinvestment Programs.

In addition, the 45Y technology-neutral production tax credit (PTC) and 48E technology-neutral investment tax credit (ITC) are available for all new nuclear projects (see figure below). Recent changes to the tax code for elective pay and transferability not only removed barriers for tax-exempt and governmental entities to receive the tax credit value but also allowed project developers to sell their tax credits instead of entering a tax-equity partnership.

IRA provision	Description	Adders	Notes
48E: investment tax credit (ITC)	Provides 30% of the capital cost for a nuclear plant back in tax credits	+10% for siting in energy communities +10% for use of domestic content	**Facility eligible for both adders would get 50% effective ITC**
45Y: production tax credit (PTC)	Provides an inflation adjusted $25/MWh in tax credits for every MWh of power produced by a nuclear plant	+10% for siting in energy communities +10% for use of domestic content	**Must choose ITC or PTC (not both)**

Source: U.S. Department of Energy, Pathways to Commercial Liftoff: Advanced Nuclear (2023), p. 28

Finally, smaller awards are available through certain programs such as the GAIN Nuclear Energy Voucher Program and Advanced Research Projects Agency–Energy (ARPA-E). While these programs would benefit project exploration, they would not be at the necessary scale to spur new nuclear construction in Texas.

Based on this landscape, the biggest federal programs to support new nuclear power in Texas include the Loan Program Office and technology-neutral tax credits. While these provide significant incentives, they may not be enough to catalyze widespread deployment due to financing uncertainty about potential cost and schedule overruns. Targeted state-level programs as discussed in the Recommendations section of the main report can address and enable Texas to be a leader in new nuclear deployment.

Appendix G: Demonstration Projects

West Texas Produced Water and Desalination With Nuclear Power

Nuclear power deployed for electricity can also produce new water supply and manage produced water from hydrocarbon production in Texas. New nuclear reactors provide an opportunity to solve both power and water issues in Texas.

Reactors can be built to provide power when needed and divert heat to desalination of seawater on the coast, brackish water from underground aquifers, and treatment of produced water from oil and gas production. An economic and technical study and demonstration plant will jumpstart the nuclear water desalination discussion in Texas.

Texas is projected to increase water demand from 17.7 million to 19.2 million acre-feet per year, depleting already stressed aquifers. The State Water Plan proposes spending $80 billion over the next 45 years to solve the shortfall and avoid $153 billion in economic damages.[1] Nuclear reactors can be dispatched to produce energy when electricity is valuable and provide energy to new water supply operations when electricity from other generation sources is plentiful and demand is low.

Nuclear power can solve another high-profile water problem in Texas – disposal of produced water from hydraulic fracturing during oil and gas production. Produced water is currently disposed by injecting it into deep underground formations, which has increased seismic activity in some areas.[2] Removing salt and hydrocarbons from the produced water using nuclear reactors would solve the disposal problem and result in a new clean water supply.

The key to deploying nuclear power to solve the state's water supply challenges and produced water impacts is to determine the incentives necessary to make these systems a viable alternative to current technologies. A ANR optimized to produce power when electricity prices are high and water when electricity prices are low will have entirely different economics associated with desalination, potentially making nuclear power based thermal desalination an economically viable pathway.

Permian Energy Production With Advanced Nuclear Power

The Permian Basin of West Texas has experienced significant load growth due to the electrification of oil and gas (O&G) production and future load projections indicate continued increases. Building power generation capacity within the Permian Basin would reduce the need for ERCOT to construct additional transmission infrastructure to meet the growing power demand in the region.

In April 2024, Diamondback Energy, an O&G operator, and Oklo, a microreactor developer, signed a Letter of Intent (LOI) to help bridge 50MW of power demand, signaling both value acceptance and business appetite for nuclear power within the Permian. In addition, Shepherd Power, a subsidiary of NOV, an oil and gas fabricator, has been working with the NRC and large Permian producers to work through the siting and regulatory issues for an advanced reactor.

Texas could work with advanced reactor developers and Permian O&G operators to deploy nuclear power/heat to demonstrate successful deployment of nuclear power for the O&G industry. The resulting demonstration plant would produce less than 100MW power and bring together a consortium of a nuclear reactor company, a developer, and an O&G operator who provided land for siting.

Advanced Nuclear Reactors on University Campuses, Microgrid on Texas A&M Rellis Campus
Universities in Texas have significant energy needs and have proven that power sources located on campus significantly reduce utility energy costs. University reactors also have the potential to contribute to advancing licensing, supply chain, and construction expertise for the ANR industries. Additionally, ANRs could also be used to further the science of nuclear medicine.

Advanced nuclear reactors for research and demonstration are a critical first step in nuclear workforce development and education that requires less time and money to build. Additionally, ANRs on university campuses would enhance grid stability, address energy supply shortages, provide long-term cost savings for universities, and enhance public acceptance of nuclear power in an environmentally responsible manner.

Supporting demonstrations university campuses would provide the state with a chance to accelerate the engineering, licensing, supply chain, construction experience, and workforce development that will bring costs down for ANRs in Texas.

Texas A&M has begun to explore the opportunity for a nuclear power source opportunity with a solicitation for the RELLIS Nuclear Reactor Project. The vision is to develop a nuclear energy proving ground on the Texas A&M RELLIS campus.

In addition to supplying power to the A&M Campus, the RELLIS project microgrid would be a test bed for research which is a critical first step in supplying the future workforce development and education for new reactor technologies.

The project seeks to demonstrate advanced nuclear reactors, , including but not limited to Generation III+, Generation IV, and fusion power plants technologies, to provide clean, firm capacity to the electrical grid and aims for up to a gigawatt of total capacity over time. Initially, a research test bed ranging from 1 MW to 10 MW is also being explored. The project may also feature shared infrastructure such as plant cooling systems, electrical regulation and grid interconnects, transmission facilities, site regulatory approvals, educational and training facilities, safety infrastructure, administrative offices, and testing and development facilities, all maintained by a collaboration of stakeholders. The proving grounds will also host activities and associated liabilities that are fully managed and maintained by the individual respondents.

> *"As Texas continues to grow, it is critical that we add more reliable, dispatchable power for all Texans,"* said Gov. Greg Abbott. *"Texas A&M's announcement to bring advanced nuclear technologies to its RELLIS campus is essential for Texas to expand our nuclear power capabilities that will help bolster our electric grid. Nuclear energy will continue to play an integral role in Texas so we can continue to meet the energy needs of our great state for generations to come."*

Supporting a demonstration such as the Rellis Nuclear Project would provide the state with a chance to accelerate the development and site work for this effort and develop a template for reactor microgrids at other universities in Texas.

Advanced Reactor Demonstration Opportunity in San Antonio with Military & Industry
In February 2024, Joint Base San Antonio (JBSA), the City of San Antonio, CPS Energy, and the Air Force signed a first-of-its-kind memorandum of agreement to explore long lead time sources of resilient carbon free energy including new nuclear technologies. JBSA's current reliance on off-site electricity production to support its critical globe-spanning missions in air, land, sea, space, and cyberspace creates mission risk from power disruptions created by extreme weather and cyber security related attacks.

The Air Force recognizes these risks and must comply with a Congressional mandate under the 2022 National Defense Authorization Act to provide its critical missions with 99.9 percent reliable energy by 2030 and will enter long-term purchase power agreements (PPAs) to gain access to reliable energy. The Air Force and JBSA will likely be early adopters of new nuclear electricity production and can offer land and security for such a facility through enhanced use lease agreements for behind and in front of the meter production.

However, there is a greater opportunity to meet growing demand from the 42 data centers operated by 11 commercial providers, numerous federal entities, as well as the State of Texas that are clustered in San Antonio. Developing a small modular reactor on JBSA through a developer partnership, CPS Energy and other high demand users could prove to be a valuable partnership that together can solve the many issues that these first of a kind plants face.

To this end, the Texas Economic Development Commission and Texas Military Preparedness Commission should work to accelerate the opportunity for advanced nuclear in San Antonio with the military and industry. The separate line for funding for the Defense Economic Adjustment Grant Program (DEAAG) for ANR projects could help achieve this goal.

Coastal Desalination Demonstration Project – Corpus Christi

The Coastal Marine seawater desalination project, likely in the Port of Corpus Christi and directly connected to the Gulf of Mexico offers a scalable solution for water resource development. In 2023, the state legislature allocated $1 billion from general revenue to the Texas Water Fund, managed by the Texas Water Development Board, to support large-scale water resource projects.

Desalination facilities with capacities of 100 million gallons per day (MGD) or more, strategically located along the Texas coast, could form the backbone of a state-wide strategy to meet increasing water demands. The synergy between micro- and small modular nuclear reactors and desalination processes is well-documented. Integrating these processes with hydrogen production could provide significant economic benefits, positioning Texas as a global leader in low-carbon hydrogen production.

Hydrogen Production Demonstration – Houston Ship Channel

A demonstration project for using nuclear power to develop hydrogen, most likely in the Houston ship channel area, involves several key characteristics. Understanding the feasibility of integrating nuclear reactors with hydrogen production technologies at a specific site could lay the groundwork for an actual plant. Studying the possibility that nuclear reactors could provide the necessary heat and electricity to split water into hydrogen and oxygen at an economic cost is valuable to both advanced nuclear market and the hydrogen market.

The primary goal of this demonstration is to produce hydrogen without carbon emissions, leveraging the clean energy generated by nuclear power. Projects such as this, could easily be paired with federal demonstration dollars since they are at a pilot scale, meaning they are smaller than commercial operations but large enough to provide meaningful data and insights. This type of demonstration project could assess the economic viability and technical performance of using nuclear power for hydrogen production in Texas, one of the largest global hydrogen markets in existence today.

Appendix H: Complex Items to Continue to Explore

After a year of exploration and debate on many key issues and topics related to ANRs development in Texas, the Texas Advanced Nuclear Reactor Working Group identified the following complex issues that merit further exploration beyond what the Working Group has achieve thus far. Exploring these topics is a means to accelerate the certainty and funding for the commercial nuclear industry in Texas.

Expansion of N-Stamp Certificates: Many components and processes for nuclear construction and operation require vendor certification. The American Society of Mechanical Engineers (ASME) sets standards and conducts rigorous audits of organizations under its Nuclear Quality Assurance (NQA) program. Currently Texas has 4 companies that are certified as "N-stamp" by the ASME and in accordance with the NRC code. These N-stamp companies are critical to building and fabricating critical nuclear components, like pressure vessels, pumps and valves. Expanding the number of N-stamp companies in Texas would help us contend for leadership in the fabrication of components and modules.

Critical Minerals: The future fabrication of ANRs will necessitate the use of numerous critical minerals. Now is the time to work with federal officials and determine which of the most important crucial minerals can be produced at home or with friendly allies.

Texas Nuclear Fuel Recycling: Texas should contemplate and discuss a state position on the development of a nuclear recycling facility to reduce high level radioactive waste in the U.S. and to manage a "reserve' of future fuel for new reactor types.

Advanced Reactor Fuel Supply High-Assay Low-Enriched Uranium (HALEU) is not yet widely commercially available domestically. At present only Russia and China have the infrastructure to produce HALEU at scale. Centrus Energy, in the United States, began producing HALEU from a demonstration-scale cascade in October 2023.

For Texas to be a leader in advanced reactor deployments, there needs to be a reliable, low-cost, domestic fuel supply chain that produces HALEU and TRi-structural ISOtropic particle fuel (TRISO) and possibly other fuels at scale. There are companies ready to enter this space, but they need a firm buyer and injection of capital to build the facilities. Texas should consider becoming a leader by encouraging build-out of the ANR fuel supply chain. Incentives to establish a giga-scale factory and fuel chain facilities in Texas could prove to be another effort that would put Texas at the center of the global advanced nuclear industry.

Support at Existing Sites for Large Reactors. Texas has 2 existing nuclear power plants, Comanche Peak and South Texas Project. Both sites have 2 units with the ability to develop 2 more at each site. This would double Texas' currently nuclear capacity, making each site a 5,000 MWs nuclear facility. Currently, the owners are trying to understand the risks and opportunities for constructing the same design and/or smaller advanced reactor designs. Supporting these efforts would help the dispatchable fleet in Texas and utilize the existing sites to their full potential.

Additionally, the Texas Advanced Nuclear Reactor Working Group identified considerations related to **market design** to support new advanced nuclear energy efforts that can make the Texas grid more attractive. However, the Working Group ultimately deciding to first allow other outstanding market design issues settle and better understand the existing market design tools in place—including the legislatively mandated Dispatchable Reliability Reserve Service (DRRS) and the future of the Performance Credit Mechanism (PCM)—before making any specific nuclear market design recommendations. The Authority or other state entity could continue to evaluate any of these options in greater detail at a more appropriate time. Such considerations could include a regulated nuclear generation segment, advanced nuclear price floor, or a nuclear portfolio standard.

Appendix I: Acronyms

This section lists key acronyms used in this report and industry. Additional acronyms or nuclear power industry terms can be found in the NRC's glossary and supplemental Collection of Abbreviations.

ANR	Advanced Nuclear Reactor	**MWe**	Megawatts electric
BIL	Bipartisan Infrastructure Law	**NEC**	Nuclear Energy Credits
BOAK	Between a first and Nth of a Kind	**NEI**	Nuclear Energy Institute
BWR	Boiling Water Reactor	**NOAK**	Nth-of-a-Kind
CFE	Carbon Free Initiatives	**NPP**	Nuclear Power Plant
CWIP	Construction Work In Progress	**NRC**	Nuclear Regulatory Commission
DOE	Department of Energy	**O&M**	Operation & Maintenance
ERCOT	Electric Reliability Council of Texas	**OCC**	Overnight Capital Cost
FOAK	First-of-a-Kind Technology	**ORNL**	Oak Ridge National Laboratory
FPS	Fission Power Systems	**PPA**	Power Purchase Agreement
HALEU	High-Assay Low-Enriched Uranium	**PUCT**	Public Utility Commission of Texas
HPR	High Pressure Reactor	**PWR**	Pressurized Water Reactor
HTGR	High Temperature Gas Reactor	**SFR**	Sodium-Cooled Fast Reactor
LEU	Low-Enriched Uranium	**SMR**	Small Modular Reactor
LMCR	Liquid Metal Cooled Reactor	**TEES**	Texas A&M Engineering Experimentation Station
LWR	Light Water Reactor	**TEF**	Texas Energy Fund
MSR	Molten Salt Reactor	**TIEC**	Texas Industrial Energy Consumers

Membership and Acknowledgements

This report was prepared by the Texas Advanced Nuclear Reactor Working Group under the direction of PUCT Commissioner Jimmy Glotfelty and Director of the Texas Advanced Nuclear Reactor Working Group, V.A. Stephens.

Working Group Members

Chrissy Borskey, GE Vernova/GE Hitachi
Bret Colby, CPS Energy
Ryan Duncan, Last Energy
Derek Haas, The University of Texas at Austin
Maynard Holt, Veriten
Mike Kotara, Zachry Sustainability Solutions
Stephanie Matthews, Texas Association of Business
Sean McDeavitt, Texas A&M University
Andy Meyers, Ft. Bend County Commissioner
Andy Nguyen, Constellation
Preeti Patel, Dow
Ryland Ramos, Entergy Texas
Benjamin Reinke, X-Energy
Doug Robison, Natura Resources
Clayton Scott, NuScale
Jim Stanway, Samsung
Pablo Vegas, ERCOT

Acknowledgements

The Working Group greatly appreciates and acknowledges the over 80 additional experts who joined the effort and especially appreciates and acknowledges the following who volunteered countless hours:
Dani Zigon, The University of Texas at Austin (UT Austin)
Jess Heck, PUCT
Daniel Womack, Dow Chemical
Casey Kelley, Constellation
Jonas Kersulis, ERCOT
Gordon Drake, ERCOT

Monica Barchenger, ERCOT
Marcus Benavides, ERCOT
Phillip Spenrath, Wharton County Judge
Frank New, Rockwall County Judge
Brett Rampal, Veriten
Matt Handel, NextEra Energy
Ryland Ramos, Entergy
Ned Bonskowski, Vistra Corp.
Brooke Trammell, Xcel Energy
Damon Withrow, Xcel Energy
Yasmin Hassan, Texas A&M University
Valerie Segovia, Texas A&M
Dr. Kevin Clarno, UT Austin
Panel Tsvelkov, UT Austin
Greg Schulze, Exxon
Lauren Lumsden, PUCT
Tyler Nicholson, PUCT
Jacob Bulzak, PUCT
Drake Kirk, PUCT
Jack Belcher, Cornerstone
Andrew Harmon, Natura Resources
Niko McMurray, ClearPath
Casey Kelly, ClearPath
Christine King, Gateway for Accelerated Innovation in Nuclear (GAIN)
Betsy Madru, Envoy Public Labs
Michael Gruener, Motus Energy
General Michael “Apollo” Lovell, Joint Base San Antonio
Riley Choquette, Baylor University
Tighe Smith, Paragon Resources
Tim Williamson, NOV/Shepherd Power
Kristy Hartman, Nuclear Energy Institute
Maria Korsnick, Nuclear Energy Institute
David Wright, Nuclear Regulatory Commissioner
Andrea Sheridan, UT Austin
Bobby Janecka, Texas Commission on Environmental Quality (TCEQ) Commissioner
Ashley Forbes, TCEQ

Lisa Bruedigan, Texas Department of State Health Services
Shana Joyce, TX Oil & Gas Association
Katie Coleman, Texas Industrial Energy Consumers
Tony Bennett, Texas Association of Manufacturers

A special thanks goes out to Bruce Kellison, Director of the Bureau of Business Research, IC^2 Institute, and his team at The University of Texas at Austin for their multi-pronged study of economic impact. And last but not least, we thank Oak Ridge National Laboratory for preparation of all OR-SAGE siting analysis of 61 chosen sites contributing to laying the foundation for future siting strategy in Texas.

Texas Advanced Nuclear Reactor Working Group

LEARN MORE

https://www.puc.texas.gov/industry/nuclear/