EXPANDING AMERICAN ENERGY:

THE CASE FOR NUCLEAR REVIVAL

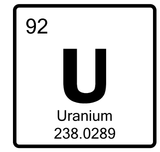
THIS BRIEF CONSOLIDATES FIVE REPORTS:

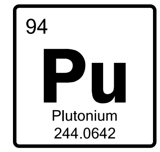
- **OPERATIONAL SAFETY OF NUCLEAR POWER PLANTS,**
- **EMERGING FUTURE OF NUCLEAR POWER,**
- **HOW NUCLEAR WASTE IS HANDLED AND STORED,**
- **ECONOMIC AND OPERATIONAL CHALLENGES FACING NUCLEAR POWER IN TEXAS, &**
- **OPPORTUNITIES TO EXPAND NUCLEAR POWER GENERATION IN TEXAS.**

Life:Powered

A Project of the Texas Public Policy Foundation

INTRODUCTION





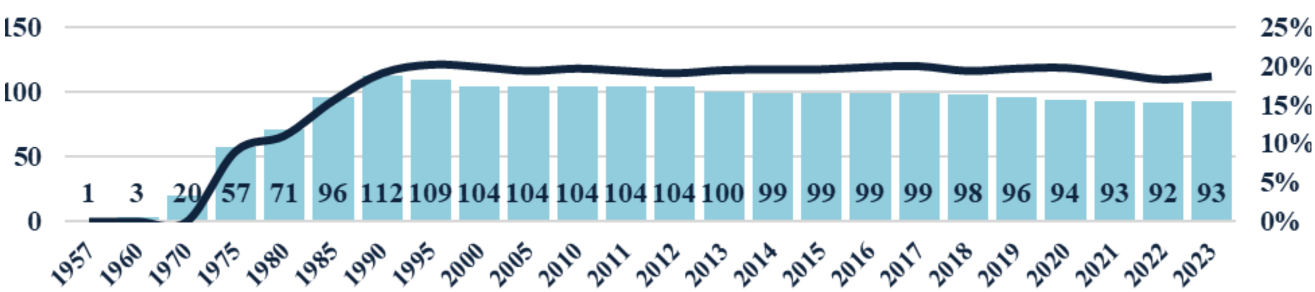
For over six decades, the United States has reaped the benefits of round-the-clock reliable electricity generation from nuclear power. Nuclear is the most-energy dense, reliable, and safest form of electricity production and has provided energy for millions of people throughout Texas since the 1990's. More than 18,500 operational reactor-years and decades of continuously improving operational safety features reveal how nuclear technology meets the safety thresholds set by regulatory agencies (World Nuclear Association, 2024). Paradoxically, nuclear power plants are the most heavily regulated aspect of the electricity business.

Texas has a remarkable opportunity to expand nuclear electricity production. In contrast to wind and solar, the extremely energy-dense and reliable uranium and plutonium fuel provides a reliable source of energy. Texas is a major hub of business and commerce in the United States, and there is a critical need to meet the current and future demands of rapid growth. ERCOT forecasts that the total annual load will double from 2023 to 2029 (ERCOT, 2024a, p.4).

OPERATIONAL SAFETY OF NUCLEAR POWER PLANTS

Figure 1

Number of Nuclear Power Reactors Compared to Percent Share in Electricity Generation in the U.S. 1957-2023



Note. Data from Total Operable Units for 1957-2023 from the Nuclear Energy Overview by the U.S. Energy Information Administration, 2024 (https://www.eia.gov/totalenergy/data/monthly/pdf/ sec8_3.pdf); Nuclear Share of Electricity Net Generation for 1957-2023 from the Nuclear Energy Overview by the U.S. Energy Information Administration, 2024 (https://www.eia.gov/totalenergy/data/monthly/pdf/sec8_3.pdf).

Presently, 94 nuclear reactors are operating in the United States, providing nearly 20% of the nation's electricity. **Figure 1** depicts the flatline of electricity generation compared to growth of nuclear in the United States. Since the rapid expansion of nuclear power in the 1990s, only three reactors have been built (U.S. Energy Information Administration, 2024).

Regulatory hurdles established after the Three Mile Island accident in 1979 increased the cost of building nuclear power plants significantly, and the events of Chernobyl (1986) and Fukushima (2011) incited further regulations (World Nuclear Association ,2024).

All nuclear power in the United States currently comes from two types of reactors:

PRESSURIZED WATER REACTORS (PWRS) & BOILING WATER REACTORS (BWRS)

All PWRs and BWRs are equipped with both passive and active safety features, providing multiple layers of defense. They also operate under strict oversight and comprehensive regulatory standards. This report focuses on the safety features, procedures, and operational systems of nuclear power plants. Active safety systems, which rely on mechanical operation and energy, and passive safety systems, which function independently of mechanical systems, work together to ensure the highest level of safety.

OPERATIONAL SAFETY OF NUCLEAR

Continued:

Reactor safety is assured by certain design elements that prevent adverse scenarios during operation. There are **five** distinct barriers to prevent the release of fission products: pellets, cladding, vessel, containment structure, and reactor building.

One key safety feature in both designs is the **negative temperature coefficient** and the **negative void coefficient.**

A negative temperature coefficient means that as the temperature rises, the reaction becomes less efficient. Similarly, a negative void coefficient indicates that when steam forms in the cooling water, it slows down neutrons and moderates the nuclear chain reaction. Experiments from the 1950s and 1960s tested these concepts by intentionally pushing facilities to their limits, confirming that the negative temperature coefficient is self-limiting even in high-reactivity situations. These experiments successfully validated this behavior in both PWR and BWR designs (World Nuclear Association, 2024). Other safety features discussed in the report include:

- **Shutdown Operations:** Protocols for severe accident management (SAM).
- **Emergency Core Cooling Systems:** Both high-pressure and low-pressure systems.

SAFETY OF NUCLEAR WASTE

Major concerns regarding the operational safety of nuclear facilities parallel those related to waste safety. Ionizing radiation is produced during nuclear fission and from the decay of nuclear fuels and their radioactive byproducts. Nuclear waste consists of solid pellets of uranium or plutonium stacked into rods, as well as the radioactive products created by splitting those atoms. Fission creates high energy particles (radiation) that can cause damage to human cells in large quantities. That's why radiation exposure from nuclear power plants and nuclear waste is tightly regulated by the Nuclear Regulatory Commission (NRC). Although there have been many innovative proposals for long-term storage of radioactive waste in the United States, the majority of waste from nuclear power plants is currently stored on-site of the nuclear facility. It is possible for waste to be repurposed and utilized again, and it can ultimately be stored safely in perpetuity. However, the U.S. has not reprocessed fuel since 1977 (GAO, 1980) and, with the delay of the Yucca Mountain project in Nevada, has no long-term storage facilities.

EMERGING FUTURE OF NUCLEAR POWER

Because of these economic and regulatory challenges, there is a growing interest in more advanced nuclear reactor designs that are smaller and even more resistant to accidents than traditional gigawatt-scale light-water reactors (LWRs). The re-envisioned reactor designs, which typically use non-light-water coolants and moderators like molten salt, are expected to mitigate the time and cost for permitting and the high capital costs that traditional nuclear reactors are subject to. Most of these reactors are designed to be small modular reactors (SMRs), which are defined by the International Atomic Energy Agency as "nuclear reactors with a generation capacity of 300 MW or less", with some as small as 1-10 MW, classified as microreactors. Their smaller size opens up the potential for different types of on-grid uses and a variety of off-grid applications.

Features of advanced nuclear reactors covered in the report include:

- **Size and Safety Features**
- **Modularity-Standardized Designs**
- **Advanced Fueling**
- **Economies of Scale vs. Economies of Numbers**

ECONOMIC AND OPERATIONAL CHALLENGES FACING NUCLEAR POWER IN TEXAS

A simple way to demonstrate how challenging the market conditions are for nuclear in Texas is to compare the cost of building and operating a nuclear power plant to the average prices in the ERCOT wholesale market. A nuclear power plant relies primarily on energy market prices since it runs constantly and has limited ability to earn extra revenue in the ancillary service market. The average price in the real-time market across the last nine years is $52.38/MWh (Potomac Economics, 2023). The levelized cost of building and operating a nuclear power plant globally is in the range of $50-$100/MWh (World Nuclear Association, 2023), and the cost in the U.S. is likely to be much higher (Amy, 2024). Therefore, there was not enough market revenue in ERCOT over the past decade—even with a once-in-century event like Uri—to support construction of a new nuclear power plant.

Table 1

Average real-time energy prices and natural gas prices in the ERCOT region: 2014 to 2022

	2014	2015	2016	2017	2018	2019	2020	2021	2022
Energy Prices ($/MWh)									
ERCOT	**$40.64**	**$26.77**	**$24.62**	**$28.25**	**$35.63**	**$47.06**	**$25.73**	**$167.88**	**$74.92**
Houston	$39.60	$26.91	$26.33	$31.81	$34.40	$45.45	$24.54	$129.24	$81.07
North	$40.05	$26.36	$23.84	$25.67	$34.96	$46.77	$23.97	$206.39	$75.52
South	$41.52	$27.18	$24.78	$29.38	$36.15	$47.44	$26.63	$187.47	$72.96
West	$43.58	$26.83	$22.05	$24.52	$39.72	$50.77	$31.58	$105.27	$64.53
Natural Gas Prices ($/MMBtu)									
ERCOT	$4.32	$2.57	$2.45	$2.98	$3.22	$2.47	$1.99	$7.30	$5.84

Note: Data from 2022 State of the Market Report for the ERCOT Electricity Markets, Potomac Economics, 2023 (https://www.potomaceconomics.com/wp-content/uploads/2023/05/2022-State-of-the-Market-Report_Final_060623.pdf).

Even if a nuclear unit could be built and operated at a levelized cost of $50/MWh or less, any investor looking at the data in **Table 1** would be hesitant to invest in a project that will only make money two or three years out of every ten years. The problem is especially acute for a high capital cost unit like a nuclear reactor because no bank will issue a huge loan on a project with such uncertain payouts and an unknown payback period.

The risk of the project developers missing their revenue projections for a few years in a row and defaulting on the loan is simply too high. Therefore, the largest economic barrier to nuclear—or any type of baseload power generation in Texas—is the timing and certainty of future revenues. The expansion of wind and solar increases a volatility in ERCOT and promotes “peaker” units rather than reliable baseload generation.

Until market reform is accomplished, the best way to bring nuclear energy to Texas would be for companies to co-locate small reactors with data centers or industrial facilities, rather than relying on the bulk power grid to meet energy needs.

Companies claim that they run on 100% emissions-free electricity through power purchase agreements with wind and solar. In reality, they are subsidizing variable wind and solar generation by purchasing credits, while still depending on reliable resources that are powering the entire grid, which are mostly fossil fuels.

These companies should be required to co-locate or contract with a nuclear facility or a natural gas facility equipped with carbon capture, so that they are truly consuming emissions-free energy and improving—rather than degrading—the reliability of the grid by doing so.

OPPORTUNITIES TO EXPAND NUCLEAR POWER GENERATION IN TEXAS

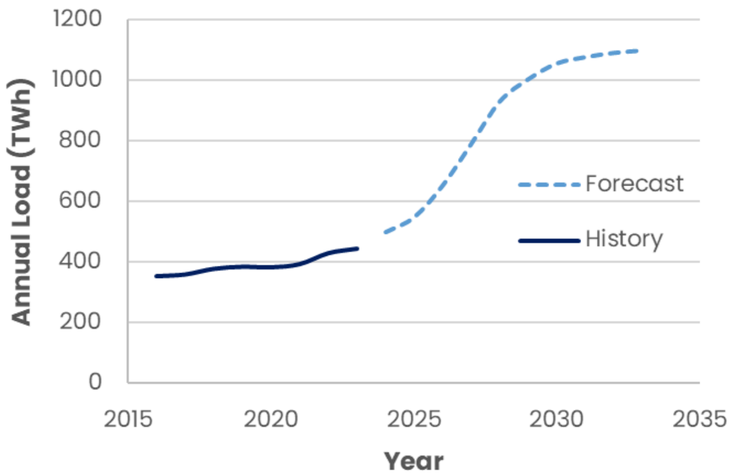
Four nuclear power reactors are currently operating in Texas: Comanche Peak Units 1 and 2 in Somervell County, and South Texas Project Units 1 and 2 in Matagorda County. The Comanche Peak units each produce approximately 1,218 MW and are operated by Vistra Operations Company LLC (United States Nuclear Regulatory Commission, 2022a). The South Texas Project reactors produce approximately 1,250 MW each and are operated by the STP Nuclear Operating Company, which is a joint venture of Austin Energy, CPS Energy, and Constellation Energy (United States Nuclear Regulatory Commission, 2022b). All four facilities are pressurized-water reactors.

Nuclear power is a weather independent, low land use, and emissions-free way to provide reliable power. It is the most weather-resilient form of electricity generation because it does not need to be continuously supplied with fuel. This resiliency was demonstrated during Winter Storm Uri in February 2021. One of the nuclear units at the South Texas Project went down for two days due to a frozen water pump, but the other three Texas nuclear units performed without fail. Solar, wind, and gas power plants all had significant fuel supply problems, but the total availability rate for the Texas nuclear fleet for the week was over 80%, which was better than any other generation source (ERCOT, 2021).

Policymakers are focusing on carbon emissions reduction, and the only way to ensure grid reliability is through nuclear. Nuclear energy production does not emit carbon dioxide or air pollutants while producing electricity. Its only byproducts are the leftover elements from the fission reaction. While wind and solar generation can make the same zero-emissions claim, no wind and solar generation could exist on the grid independent of quick-start natural gas generators to back them up when their production drops.

Figure 2

Historical and Forecasted ERCOT Annual Load



Data from 2024 ERCOT System Planning Long-Term Hourly Peak Demand and Energy Forecast (https://www.ercot.com/files/docs/2024/01/18/2024_LTLF_Report.docx).

Texas has the resources, workforce, and business-friendly environment necessary to build and operate new nuclear power plants. The U.S. Geological Survey (Mihalasky et al., 2015) and the Texas Bureau of Economic Geology at the University of Texas at Austin (Bureau of Economic Geology, n.d.) have found that there are enough unmined uranium deposits along the Texas Gulf Coast to power the entire U.S. electric grid for approximately five years. This local resource could be a source of economic growth and many high-paying jobs if nuclear energy experiences a revival in Texas.

Texas can also develop the human capital and expertise to power a nuclear renaissance. Texas A&M University at College Station and the University of Texas at Austin each house research reactors, and Abilene Christian University is currently building a molten salt research reactor. These facilities could serve as core workforce development centers if nuclear energy re-establishes itself in Texas. Furthermore, thanks to the continued growth of the oil and gas industry, Texas has the largest industrial manufacturing workforce in the country with the expertise needed to build the infrastructure for new power plants.

CONCLUSION:

The growth in electricity demand is projected to outstrip population growth by a large margin due to new industrial loads. As show in **Figure 2**, ERCOT forecasts that the total annual load will double before 2030. There is a significant opportunity to expand nuclear energy in Texas and across the United States, presenting both clear benefits and a pathway for growth.

Regulatory hurdles at the federal level and the economics of nuclear power have hindered nuclear expansion in the United States. To foster a more attractive environment for nuclear growth, states should focus on removing any unnecessary regulations at the state level. Texas can lead the revival of the nuclear industry while simultaneously increasing nuclear generation. The Texas Legislature has the ability leverage the full potential of nuclear power so that Texans continue to experience growth in their communities. Texas should consider implementing the following recommendations with the aim to streamline regulations and promote nuclear development.

POLICY RECOMMENDATIONS:

Military Application and Generation:

Since the 1950s, the Navy has been utilizing nuclear power capabilities for its benefits in both propulsion and safety. The U.S. military, specifically military bases in Texas, should continue to spearhead the development of new nuclear technology by funding pilot projects. Military microreactor installations get around NRC regulation, and it may be worthwhile to allow reactors on military or state land to participate in ERCOT to demonstrate viability within the existing ERCOT market.

The Department of Defense is one of the largest energy consumers in the world and Texas is the proud home to 15 active-duty military installations, contributing over $150 billion to the economy. Sites, such as the bases around San Antonio, have easy access to the grid.

Texas Permitting Officer:

Texas should establish a single point of contact for all steps in the state permitting process, with as much federal delegation to the state as possible, to improve the speed and efficiency of site permitting.

Permitting applications for future nuclear projects and the expansion of existing facilities often face significant challenges due to miscommunication among the agencies involved. The timelines for obtaining permits are unclear and can vary greatly, leading to project costs exceeding initial budgets. However, having a single point of contact who is well-versed in the latest permitting requirements could lead to a substantial return on investment.

Nuclear Site Permitting:

Federal regulations require long-term meteorological and seismic activity data when identifying sites for nuclear generation. Texas can have a quicker turnaround time on site characterization by pre-selecting potential sites for nuclear power generation and physically collecting this data on the front end.

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Contact:
Carson Clayton
cclayton@texaspolicy.com

Texas Public Policy Foundation

@Lifepowered

@Lifepowered

lifepowered.org