VOLUME 49, NUMBER 1 / Winter 2025

SECTION REPORT

OIL, GAS & ENERGY RESOURCES LAW
SECTION OF THE STATE BAR OF TEXAS

www.oilgas.org

IN THIS ISSUE

Chair's Message
Oil, Gas & Energy Resources Law Section

In the hit streaming series *Landman*, the main character portrayed by Billy Bob Thornton argues that "alternative" energy is not necessarily "clean" energy. Citing the diesel, steel, concrete, heavy machinery and oil needed to manufacture a single wind turbine, Mr. Thornton's posits that "in its 20-year lifespan, [the wind turbine] won't offset the carbon footprint of making it." Those of us that work on energy matters know that despite some misgivings about renewables, they are here to stay and constitute an ever-growing piece of the power puzzle in Texas. As such, it is imperative that we learn more about renewable energy in all of its forms, and stay current on Texas law dealing with the subject.

This is OGERL's third Section Report focused exclusively on renewables, and more specifically in this volume, on nuclear energy. From issues surrounding the security of small modular reactors to how nuclear cogeneration fits within our energy industry in Texas, this volume of the Section Report covers the gamut of nuclear-related issues. The authors include international and domestic academics, advocates for the responsible disposal of nuclear waste, as well as small-firm and large-firm practitioners. A special thanks is owed to Brent Stahl, who has once again taken the lead as editor for this special renewables-only Section Report.

As reminder, OGERL is co-sponsoring two continuing education seminars in early 2025. First, the 11th Annual State Bar of Texas Oil and Gas Disputes Course will be held on January 16-17 in Houston at The Chifley Hotel (Anna Brandl, Course Director), and will be yet another comprehensive seminar on dealing with disputes in the energy industry. A few weeks later, the 20th Annual University of Texas Law CLE Renewable Energy Law Essentials and Institute will be held on February 3-5 in Austin at the AT&T Conference Center (Brent Stahl, Course Director), and it will once again bring together leading attorneys and industry experts in wind, solar, battery storage and hydrogen for three days of the latest developments affecting renewable energy projects in Texas and nationwide.

OGERL's inaugural Leadership Academy class is having its third and final meeting on February 6-7 in Austin. The feedback from the participants, faculty and sponsors from this program has been outstanding, and we are excited to see where the Leadership Academy graduates go from here!

The OGERL Council will sponsor a networking reception for our North Texas members at the Joule Hotel in Dallas on Thursday, March 27. An email blast will be sent out in the coming weeks with additional details.

Finally, I want to remind all members about OGERL's website. The website is located at www.oilgas.org. You will find up to date information for the Section as well as electronic copies of past Section Reports and seminar papers. Hopefully, the OGERL website can assist you in your practice.

Thank you for your continued support, and please enjoy this Section Report.

Sincerely,

J. Byron "Trace" Burton, III
Chair, Oil, Gas and Energy Law Section of the
State Bar of Texas

Editor's Message
Oil, Gas & Energy Resources Law Section

Welcome to the inaugural edition of an OGERL Section Report on nuclear energy topics.

2024 saw significant announcements regarding small modular reactor (SMR) nuclear energy projects, all to facilitate growing demand for electricity. The increased electricity needs result from planned data centers for the Artificial Intelligence (AI) industry. These AI data centers are focused on securing sufficient electricity that is less dependent on grid fluctuations – many of the planned projects will be comprised of behind-the-meter facilities located near data centers in which the electricity output is reserved solely or largely for the specific data center.

Google, *Microsoft*, *Meta*, and *AWS* are all working toward using more electricity from SMR facilities. Just last month, a large data center company, *Switch*, announced an agreement with *Oklo* to supply 12 Gigawatts of nuclear generated electric power through 2044. The Texas Nuclear Alliance hosted the 2024 Texas Nuclear Summit on November 17, 2024, in Austin, Texas, with more than 350 attendees. Texas' PUCT Commissioner Jimmy Glotfelty spoke at the conference explaining how SMR facilities can play a role in meeting Texas' anticipated electricity needs. And on the same day as the conference, Texas Governor Greg Abbott and Commissioner Glotfelty announced the release of a report by the Texas Advanced Nuclear Reactor Working Group following a year-long study on how increased electricity generation in ERCOT may be sourced by nuclear power projects. In short, Texas will have a significant increase in nuclear powered electricity generation projects in the next 10 years and beyond.

This OGERL Section Report includes articles on seven topics related to SMR and other nuclear energy facilities: (i) "*security-by-design*" concepts to plan for the specific security needs of SMRs, (ii) technology/legal issues for spent fuel disposal, (iii) a case study on Bill Gates' *TerraPower* Natrium reactor project which commenced construction in Summer 2024, (iv) an in-depth legal analysis of federal laws/regulations surrounding interim-storage of spent fuel while facilities await adequate long-term storage, (v) a detailed overview of Texas' statutes/rules for property tax incentives available for nuclear energy projects, (vi) a summary of challenges and opportunities associated with low level radioactive waste materials, and (vii) a business case on how SMR cogeneration facilities may help meet AI data center energy demands.

OGERL extends a big thank you to the authors of this Section Report who spent countless hours researching and writing the excellent group of articles assembled for this edition. We appreciate the dedication, hard work, and thoughtful scholarship these authors bring to OGERL.

We remind you that, as a member of the Section, you can always access past Section Reports and numerous CLE presentations via the Section's website: www.oilgas.org. If you are interested in contributing an article for future Section Reports, please contact Christopher M. Hogan, the Section Report Editor for OGERL at (713) 671-5630.

Sincerely,

Brent Stahl
Editor for Vol. 49, No. 1
(512) 652-2946
bstahl@sbaustinlaw.com

PAST CHAIRS

W. H. Francis (1938-1940)
H. F. Montgomery (1940-1941)
E.E. Townes (1942-1943)
John E. Kilgore (1943-1944)
Carlos Masterson (1946-1947)
J. W. Timmins (1947-1948)
C.C. Small, Sr. (1948-1949)
R. E. Hardwicke, Sr. (1950-1951)
W. D. Masterson (1951-1952)
Jacques P. Adoue (1952-1953)
Clayton L. Orn (1953-1954)
Hayden W. Head (1954-1955)
Paul McDermott (1955-1956)
Gordon Brelsford (1956-1957)
Joe R. Greenhill (1957-1958)
Cecil N. Cook (1958-1959)
Lee Jones, Jr. (1959-1960)
Frank J. Scurlock (1960-1961)
J.O. Terrell Couch (1961-1962)
Ira Butler (1962-1963)
J.K. Smith (1963-1964)
Walter C. Beardsley (1964-1965)
W.B. Edwards (1965-1966)
Leo J. Hoffman (1967-1968)
Jack C. Hardy (1968-1969)
Dean J. Capp (1969-1970)
Simon M. Frank (1970-1971)
Hiram A. Berry (1971-1972)
Martin L. Allday (1972-1973)
Howard P. Coghlan (1973-1974)
Jesse P. Luton, Jr. (1974-1975)
J. Burleson Smith (1975-1976)
Robert E. Rain, Jr. (1976-1977)
Frank Douglass (1977-1978)
Claude E. Upchurch (1978-1979)
Edward H. Hill (1979-1980)
Guy L. Nevill (1980-1981)
Tom Scott (1981-1982)
Charles B. Harris (1982-1983)
Julius L. Lybrand (1983-1984)
Richard T. Brady (1984-1985)
J.R. ("Bob") Schneider (1985-1986)
Ernest E. Smith, III (1986-1987)
Vernon "Skipper" Lay (1987-1988)
Jan E. Rehler (1988-1989)
H. Philip ("Flip") Whitworth (1989-1990)
Stuart C. Hollimon (1990-1991)
Robert C. Grable (1991-1992)
Tevis Herd (1992-1993)
Jon R. Ray (1993-1994)
Michael L. Grove (1994-1995)
Thomas W. Lynch (1995-1996)
Richard F. Brown (1996-1997)
David G. Dunlap (1997-1998)
Elizabeth N. ("Becky") Miller (1998-1999)
Janice K. Hartrick (1999-2000)
Ernest V. Bruchez (2000-2001)
Allen D. Cummings (2001-2002)
Kevin M. Beiter (2002-2003)
David C. Houck (2003-2004)
Laura H. Burney (2004-2005)
Brian R. Sullivan (2005-2006)
Arnold J. ("Arne") Johnson (2006-2007)
Richard D. ("Dick") Watt (2007-2008)
Michael P. Pearson (2008-2009)
Norma Iacovo (2009-2010)
Fabene Welch (2010-2011)
William ("Bill") Burford (2011-2012)
Tim Brown (2012-2013)
M.C. "Cottie" Miles (2013-2014)
David Patton (2014-2015)
Ricardo E. Morales (2015-2016)
Charles W. Gordon IV (2016-2017)
Peter E. Hosey (2017-2018)
Kathleen Magruder Hiersche (2018-2019)
Michael D. Jones (2019-2020)
Michael E. McElroy (2020)
Jeff Weems (2020-2021)
Carroll Martin (2021-2022)
Katy Wehmeyer (2022-2023)
Jonathan Baughman (2023-2024)

THE SECURITY OF SMALL MODULAR REACTORS: REGULATORY CONSIDERATIONS

Chanel Chauvet-Maldonado
Nuclear Nonproliferation Regulatory Specialist
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Stephen Dahunsi
Research and Development Associate
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Arelis Colon
Intern, Oak Ridge National Laboratory
NNSA Minority Serving Institutions Internship Program (MSIIP)[1]
Oak Ridge Institute for Science and Education (ORISE)
National Nuclear Security Administration (NNSA)

I. Introduction

The deployment of small modular reactors (SMRs) marks a significant advancement in nuclear energy; offering a range of new opportunities and challenges. These compact reactors are designed to be safer and more versatile than traditional reactors, but their innovative nature necessitates a rigorous approach to security. One of the key concepts in ensuring the security of SMRs is *security-by-design*, which addresses the integration of security measures from the conceptual phase, or the beginning of the development of the technology. The aim of *security-by-design* in relation to SMRs is such that the technology is designed in a manner to support the prevention, detection, and response to intentional or criminal acts that involve nuclear and other radioactive material.[2] This proactive approach is essential for addressing the specific security needs of SMRs, which differs from those of traditional reactors because of their unique physical and operational characteristics.

To effectively secure these reactors, a graded approach to security is essential. The graded approach ensures that there are tailored security measures for SMRs in relation to the specific threats and vulnerabilities associated with the technology, rather than applying a one-size-fits-all standard. Implementing a graded approach requires careful consideration and integration into a state's legal and regulatory framework prior to the deployment of SMRs. Within the context of regulation, a graded approach can be used to determine the level of analysis, documentation, and actions required to comply with requirements. This preemptive planning is vital to address emerging threats and ensure that regulations are adequately designed to protect against potential risks.

This paper explores how regulatory considerations intersect with the concept of security-by-design for SMRs. It examines whether the responsibility for nuclear security lies with the state in this unique context; legal aspects of SMR ownership; and how security measures should be implemented

[1] ***DISCLAIMER: MSIIP interns are program participants of the NNSA Minority Serving Institutions Internship Program (MSIIP), administered by ORISE on behalf of the NNSA, and are not employees or contractors of the federal government.

Notice: This manuscript has been authored by UT-Battelle, LLC, under contract DE-AC05-00OR22725 with the US Department of Energy (DOE). The US government retains and the publisher, by accepting the article for publication, acknowledges that the US government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for US government purposes. DOE will provide public access to these results of federally sponsored research in accordance with the DOE Public Access Plan (https://www.energy.gov/doe-public-access-plan).

[2] International Atomic Energy Agency, Objective and Essential Elements of a State's Nuclear Security Regime, IAEA Nuclear Security Series No. 20, IAEA, Vienna (2013).

during the transport of SMRs. By addressing these considerations, the paper aims to contribute to the development of a robust regulatory framework that supports the secure deployment and operation of SMRs.

II. Purpose and Benefit of SMRs

SMRs were designed to overcome several limitations associated with traditional large-scale reactors, which are on fixed sites and tend to be expensive to both develop and operate. One of the many key benefits of SMRs is their ability to meet growing energy demands while overcoming some of the costs and security challenges posed by traditional reactors. Additionally, the flexible design of SMRs enables them to generate electricity in a variety of settings, including in remote and off-grid locations where conventional nuclear power plants may be impractical.[3]
The cost advantages of SMRs are also significant. Due to their smaller size and modular nature, SMRs can be constructed and operated at a lower cost compared with traditional reactors. The modular components and their smaller design reduce construction costs and the duration of the fabrication. This cost reduction arises from an SMR's reduced operational complexity as compared to its nuclear power plant counterparts. Moreover, the modular design allows for incremental investment and phased construction, thus making it more economically feasible for many states to procure power generation using this type of technology.[4]

Additionally, SMRs offer reduced maintenance requirements. Their modular design simplifies operational procedures and maintenance tasks, often incorporating features that allow for easier and less frequent maintenance compared with traditional reactors. For example, SMRs have reduced fuel requirements compared with those of traditional reactors. According to the IAEA, traditional reactors can require refueling every 1 to 2 years, whereas SMRs can operate as long as 3 to 7 years before needing to be refueled.[5] Some SMRs have even been designed to operate for up to 30 years without refueling.[6] This longer period between refueling not only enhances the efficiency and reliability of the reactors, but also reduces the need for extensive maintenance of the infrastructure.

Operational versatility is another significant advantage. SMRs are engineered to perform effectively across a range of geographical and environmental conditions. This adaptability makes them suitable for diverse applications, including locations in remote communities to areas with varying infrastructure capabilities, thus broadening their potential deployment.[7]

III. Security by Design Concept

The *security-by-design* concept entails incorporating security features directly into the design and operational framework of technology from its inception rather than for it to be considered down the line as an afterthought. This proactive approach is particularly crucial for SMRs given their innovative features and varied environments in which the technology can be deployed. By embedding security measures from the outset, the goal is to mitigate potential risks and vulnerabilities inherent to the technology.[8] For SMRs, this mitigation involves integrating robust physical protection systems, advanced cybersecurity measures, and operational safeguards tailored to their specific characteristics.

Recent research emphasizes the importance of a *security-by-design* approach in enhancing the resilience of SMRs against both physical and cyber

[3] International Atomic Energy Agency, *Advances in Small Modular Reactor Technology Developments* (International Atomic Energy Agency, 2020), https://aris.iaea.org/Publications/SMR_Book_2020.pdf.

[4] "Benefits of Small Modular Reactors (SMRs)," Office of Nuclear Energy, US Department of Energy, https://www.energy.gov/ne/benefits-small-modular-reactors-smrs.

[5] Joanne Liou, "What Are Small Modular Reactors (SMRs)?," International Atomic Energy Agency, published September 13, 2023, https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs.

[6] Joanne Liou, "What Are Small Modular Reactors (SMRs)?," International Atomic Energy Agency, published September 13, 2023, https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs.

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

[8] Evans, A., Parks, J., Horowitz, S., Gilbert, L., & Whalen, R. "U.S. Domestic Small Modular Reactor Security-by-Design." March 2021, Sandia National Laboratory. https://energy.sandia.gov/wp-content/uploads/2022/07/US_DomesticSmallModularReactorPhysicalProtectionSystemAnalysisSAND2021-0768_REV-4.pdf

threats, among others. Studies highlight that tailored physical protection systems for SMRs, which consider their smaller size and modular nature, are essential to address unique threat scenarios.[9] Additionally, implementing sophisticated cybersecurity protocols is critical to guard against digital threats, particularly given the increased reliance on digital controls in modern reactor designs. Operational safeguards, including rigorous access controls and regular security assessments, further contribute to a comprehensive security posture. Integrating these elements from the design phase helps ensure that SMRs are not only functional but also secure against evolving threats.

IV. Projection of Use of SMRs

The process for reviewing and approving SMRs varies across states, as a result of the differing regulatory climates respectively. Additionally, the timeline for SMR design development, licensing, and deployment involves several stages, from conceptual design to regulatory approval and construction. Each phase requires rigorous evaluation to ensure state compliance with international and national safety and security standards.

Notably, the safety of people and additionally, environmental concerns continue to be a major concern in the consideration for the adoption of nuclear energy. As such, there is a great emphasis placed on licensing and the responsible use of nuclear technology, among other concerns. This point was highlighted during the 28th Conference of the Parties to the UN Framework Convention on Climate Change, where participating countries agreed to triple nuclear energy production by 2050.[10] This pledge was signed by 25 countries in 2024 who are targeting the deployment of nuclear technologies, such as SMRs and microreactors, to fulfill UN Sustainable Development Goal 7.[11] UN Sustainable Development Goal 7 is to "ensure access to affordable, reliable, sustainable and modern energy for all."[12]

SMR technology is advancing rapidly at all stages, from design to implementation. Regarding the power output, the Nuclear Energy Agency projected that the installed capacity of SMRs may reach 375 GW by 2050.[13] Moreover, the United States, United Kingdom, and Canada are accelerating the design, licensing, and commercial deployment of different advanced reactor types in the form of SMRs and microreactors.[14] China has introduced the world's first onshore commercial modular pressurized water reactor located in the Hainan province, and Russia is engaged in the deployment of this technology as well.[15]

Globally, around 80 SMR designs are presently at different stages of development and deployment in 18 countries.[16] In addition, the concept of reactor designs varies according to their power output, outlet temperature, technology and fuel cycle. Figure 2 highlights the different SMR concepts under development worldwide (See Figure 1 at end of this article -- Global Reactor Concepts).[17]

---

[9] Evans, A., Byrum, C., Stanford, D., Sandt, E., & Goolsby, T. "Physical Protection Recommendations for Small Modular Reactor Facilities". (2021) https://doi.org/10.2172/1837151. https://www.osti.gov/servlets/purl/1837151.

[10] B. Martucci, "Global small modular reactor pipeline hits 22 GW, with US leading the market: WoodMac," Utility Dive, 12 March 2024. [Online]. Available: https://www.utilitydive.com/news/small-modular-reactor-haleu-ge-hitachi-nuscale/709978/.

[11] B. Martucci, "Global small modular reactor pipeline hits 22 GW, with US leading the market: WoodMac," Utility Dive, 12 March 2024. [Online]. Available: https://www.utilitydive.com/news/small-modular-reactor-haleu-ge-hitachi-nuscale/709978/.

[12] United Nations, SDG 7 "Ensure access to affordable, reliable, sustainable and modern energy for all" https://sdgs.un.org/goals/goal7.

[13] NEA, "The NEA Small Modular Reactor Dashboard No.7650," Nuclear Energy Agency (NEA), Boulogne-Billancourt, 2023.

[14] Enerdata, "Worldwide SMR Technology Trends: An emerging technology backed by public policies," Enerdata, 20 June 2024. [Online]. Available: https://www.enerdata.net/publications/executive-briefing/smr-world-trends.html.

[15] American Nuclear Society, "China's new Linglong One reactor just one piece of nuclear explanation," 13 March 2024 [online]. Available: https://www.ans.org/news/article-5861/chinas-new-linglong-one-reactor-just-one-piece-of-nuclear-expansion/

[16] Enerdata, "Worldwide SMR Technology Trends: An emerging technology backed by public policies," Enerdata, 20 June 2024. [Online]. Available: https://www.enerdata.net/publications/executive-briefing/smr-world-trends.html.; and International Atomic Energy Agency (IAEA), "Advances in Small Modular Reactor Technology Developments, A Supplement to: IAEA Advanced Reactors Information System (ARIS)," International Atomic Energy Agency (IAEA), Vienna, 2022.

[17] NEA, "The NEA Small Modular Reactor Dashboard No.7650," Nuclear Energy Agency (NEA), Boulogne-Billancourt, 2023.

The process for reviewing and approving these designs varies across the countries engaged in the deployment of this technology because of their differing regulatory climates, technologies, and safety cultures. The timeline also differs for the different stages as well, including design development, licensing, and deployment processes due to regulatory parameters. Each phase requires rigorous evaluation to ensure state compliance with international and national safety and security standards. However, the International Atomic Energy Agency's (IAEA) Nuclear Harmonization and Standardization Initiative is coordinating international efforts to standardize SMR designs and other activities, such as development, deployment, and oversight of the technology as well; the goal of which is to harmonize other relevant issues targeting a broad range of technical efforts with propositions that one day, the various designs could be subject to uniform licensing.[18]

V. Regulatory Considerations for the Security of SMRs

The regulatory framework for SMRs is currently shaped by several key international and national guidelines aimed at ensuring nuclear security. At the international level, the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment, along with the International Atomic Energy Agency (IAEA) Nuclear Security Series guidance documents, provide a comprehensive foundation for a regulatory framework for SMRs.

The CPPNM, entered into force in 1987 and amended in 2005, sets out the responsibilities of states to protect nuclear materials and facilities from theft, sabotage, and other malicious acts.[19] For SMRs, the CPPNM and its Amendment helps to ensure that states implement robust security measures that account for new designs and operational characteristics. For example, the amendment mandates that states adopt measures such as physical barriers, surveillance systems, and personnel reliability programs to safeguard nuclear materials, which are directly applicable to the protection of SMRs.[20]

The IAEA's Nuclear Security Series (NSS) provides detailed guidance on implementing effective security measures. INFCIRC/225/Rev.5, a key document, outlines international recommendations for the physical protection of nuclear material and nuclear facilities.[21] This guidance document can be used in support of a *security-by-design* approach, which is crucial for the secure operation of SMRs. It recommends that nuclear facilities, including those housing SMRs, integrate security features from the earliest stages of design and operation. This recommendation includes tailored security systems to address risks associated with SMRs, such as their modularity and smaller design, which may require different protective strategies as compared with traditional reactors.[22] INFCIRC/225/Rev.5 also highlights the importance of regular security assessments and updates to address emerging threats in order to help ensure that SMR regulations remain current and effective.

In addition to international frameworks, individual countries have developed specific laws and regulations for SMRs that account for varying security needs and regulatory environments. For instance, in the United States, the NRC has issued regulations under 10 CFR Parts 50 and 52 that address the licensing and operation of nuclear facilities. These regulations include provisions for security plans, physical protection systems, and emergency

[18] International Atomic Energy Agency (IAEA), "The SMR Platform and Nuclear Harmonization and Standardization Initiative (NHSI)," IAEA, Vienna, 2022.; Stephen O Dahunsi, "Licensing, Regulations, and Developing Guidance for Nuclear Technology Deployment for Embarking Countries in Africa," in 63rd INMM Annual Meeting - Virtual, Tennessee, United States of America, 2022.; Donald R. Hoffman, "Nuclear Power Program Development Creative Licensing Approach for New Nuclear Build – Large and Small," in Bulgarian Nuclear Energy – National , Regional and Work Energy Security Bulatom 2023 Conference , Bulgaria, 2023.; and Daniel T. Ingersoll and Mario D. Carelli, "Licensing of small modular reactors (SMRs)," in Handbook of Small Modular Nuclear Reactors (Second Edition), In Woodhead Publishing Series in Energy, 2021, pp. 279-298.

[19] Convention on the Physical Protection of Nuclear Material, amended in 2005, https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment.

[20] Convention on the Physical Protection of Nuclear Materials, https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment.

[21] International Atomic Energy Agency, *Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Revision 5, IAEA Nuclear Security Series No. 13 (International Atomic Energy Agency, 2011), https://doi.org/10.61092/iaea.ko2c-dc4q.

[22] INFCIRC/225/Rev. 5, 2011.

preparedness that could be applicable to SMRs.[23] Similarly, the UK Office for Nuclear Regulation enforces security requirements through the Nuclear Installations Act and associated security codes, which mandate detailed security assessments and protection measures for nuclear installations.[24]

a. The US Nuclear Regulatory Commission Licensing and Approval Process

The new SMR designs will require significant customer knowledge for licensing, regulations, and guidance documents to facilitate deployment and operational needs for nuclear technology. However, the responsibility to put in place comprehensive and appropriate infrastructure for the safe, secure, and sustainable licensing and deployment is the obligation of the state. The IAEA is working with countries such as the United States, Canada, Argentina, China, and Russia to create a concept of a technology-neutral framework that will address health, risk, and safety requirements and broader harmonization of regulatory and technical requirements.[25]
Furthermore, there is an additional challenge posed by multiple designs needing to be licensed as SMR designs continue to evolve. For example, an SMR design that has been licensed by a country-of-origin regulator may be subjected to local licensing requirements outside the country of origin.[26] Therefore, countries considering any of these new technologies must introduce a flexible regulatory framework to accommodate domestic and international best practices from design preapplication to the decision phase.[27]

The US Nuclear Regulatory Commission (NRC) approaches licensing and construction of new reactors using two pathways outlined in Figure 2. Specifically in Parts 50 and 52 of Title 10 in the *US Code of Federal Regulations* (CFR), there are requirements for applicants to submit joint multi-year site construction and operating license applications that address the risks and controls for operating traditional reactors at a specific site. Furthermore, the US Congress has approved the establishment of a “technology-inclusive framework for commercial advanced nuclear reactors” under the Nuclear Energy Innovation and Modernization Act.[28] Relatedly, the NRC has proposed a new 10 CFR Part 53, which will accelerate the licensing process of these new designs of advanced reactors without compromising the level of safety ensured under Parts 50 and 52 (see Figure 2 at end of this article – US NRC Licensing Options).[29]

Overall, the integration of international guidelines into national regulations ensures that SMRs are subject to rigorous security standards designed to address both conventional and emerging threats. By aligning with the CPPNM, its amendment, and IAEA NSS guidance, as well as adopting tailored national regulations, states can effectively manage the security challenges associated with SMRs.

a. Concerns

The rapid deployment of SMRs without a comprehensive and well-defined regulatory framework poses several concerns. These concerns are primarily related to the adequacy of security measures, the protection of facilities, and the potential for malicious acts.

One of the foremost legal concerns surrounding SMRs is the need for appropriate and adaptable regulatory frameworks to be in place before an SMR becomes operational in a country. Additionally, unlike

---

[23] “Part 50- Domestic Licensing of Production and Utilization Facilities,” United States Nuclear Regulatory Commission (NRC), https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/full-text.html. “Part 52- Licenses, Certifications, and Approvals for Nuclear Power Plants,” United States Nuclear Regulatory Commission (NRC), https://www.nrc.gov/reading-rm/doc-collections/cfr/part052/full-text.html.

[24] Nuclear Installations Act, 1965, United Kingdom, https://www.vertic.org/media/National%20Legislation/United_Kingdom/GB_Nuclear_Installations_Act_1965.pdf.

[25] Miklos Gaspar, “Technology Neutral: Safety and Licensing of SMRs,” International Atomic Energy Agency (IAEA), 17 August 2020. [Online]. Available: https://www.iaea.org/newscenter/news/technology-neutral-safety-and-licensing-of-smrs.

[26] Stephen O Dahunsi, “Licensing, Regulations, and Developing Guidance for Nuclear Technology Deployment for Embarking Countries in Africa,” in 63rd INMM Annual Meeting - Virtual, Tennessee, United States of America, 2022.

[27] Miklos Gaspar, “Technology Neutral: Safety and Licensing of SMRs,” International Atomic Energy Agency (IAEA), 17 August 2020. [Online]. Available: https://www.iaea.org/newscenter/news/technology-neutral-safety-and-licensing-of-smrs.

[28] Ryan Norman, “New Nuclear Reactor Licensing 101,” Third Way, 26 November 2024. [Online]. Available: https://www.thirdway.org/blog/new-nuclear-reactor-licensing-101.

[29] Ryan Norman, “New Nuclear Reactor Licensing 101,” Third Way, 26 November 2024. [Online]. Available: https://www.thirdway.org/blog/new-nuclear-reactor-licensing-101.

traditional reactors, SMRs are designed to be deployed in a variety of locations, including remote or unconventional sites. This flexibility requires regulatory frameworks that are adaptable to different geographical and operational contexts as well.[30] The absence of such regulations can lead to gaps in security, inadequate emergency response plans, and insufficient protection measures, thus rendering SMRs vulnerable to both physical and cyber threats. This vulnerability could result in facilities that are inadequately protected against potential threats or malfunctions, thereby compromising the security of the reactors.

Moreover, the security implications for SMRs differ from those of traditional reactors because of their smaller size and modular design. Traditional reactors benefit from well-established security protocols and substantial physical barriers, whereas SMRs smaller scale and modular nature present a different set of challenges that should be considered in the development of a regulatory framework for this technology. For example, the reduced physical size of SMRs might limit the extent of protective barriers, and their modularity could introduce more vulnerabilities during the transportation and assembly phases than those identified for traditional reactors. Additionally, if SMRs are deployed rapidly without adequate regulations, they could potentially become targets for malicious acts, such as sabotage or theft.

Traditional reactors also benefit from larger security infrastructures and have established procedures for managing emergencies. They are generally designed to withstand a broader range of threats due to their extensive physical protection systems and larger security teams. If the same level of regulatory rigor is not applied to SMRs, the gaps in security could lead to risks relative to their smaller size.[31] Interestingly, the smaller size of SMRs might mitigate the effects of such incidents, but could intensify the consequences, if for example, multiple SMRs were targeted in rapid succession.

b. Regulatory Considerations that Should be Accounted for in the Development of SMR-related Laws and Regulations

When developing laws and regulations for SMRs, several key regulatory considerations must be addressed to ensure their secure and effective deployment. These considerations include the state's responsibility for nuclear security, legal aspects of SMR ownership, and security measures during transport.

Regardless of whether an SMR is deployed by a private entity or a state, the state remains fundamentally responsible for nuclear security. This responsibility is enshrined in international conventions, including the CPPNM and its Amendment, which obligate states to ensure that adequate security measures are in place to protect nuclear materials and facilities against theft, sabotage, and other malicious acts.[32] Regarding privately-owned or operated SMRs, the state, as the responsible party for nuclear security, must accordingly enforce regulatory frameworks and oversee security compliance in order to uphold and maintain domestic and international security standards. This responsibility includes setting up regulatory bodies that monitor and enforce security measures and ensure that private operators adhere to strict security protocols.[33]

Legal considerations regarding SMR ownership involve several aspects, including operational responsibilities and security obligations. Ownership laws must clearly define who is responsible for the security of SMRs, including liability in the event of an incident. These laws should address issues such as the transfer of ownership, operational control, and the allocation of responsibilities between private operators and governmental authorities. Additionally, legal frameworks must ensure that operators comply with both national and international security standards, and in doing so, provide a clear delineation of roles and responsibilities to prevent any gaps in security.

Lastly, the transport of SMR units presents additional security challenges. SMRs often require

[30] Riyaz Natha, "Security Considerations for Small Modular Reactors (SMR)," Sandia National Laboratory, https://www.wins.org/wp-content/uploads/2018/11/2.-Riyaz-Natha_Security-Considerations-for-SMR-Final.pdf.

[31] G. Bentoumi, A. Chaudhuri, B. Van Der Ende, B. Sur, and D. Trask, "Safety and Security for Small Modular Reactors in Canada," International Atomic Energy Agency, https://conferences.iaea.org/event/181/contributions/15437/attachments/9190/12388/Paper_-_Safety_Security_for_SMR_in_Canada_-_G._Bentoumi_final.pdf.

[32] CPPNM, 2005.

[33] INFCIRC/225/Rev. 5, 2011.

transportation from manufacturing sites to installation locations, which necessitates stringent security measures to prevent theft, sabotage, or accidents during transit. Regulatory frameworks should thus include detailed provisions for secure transport, including the use of secure transport containers, armed escorts, and real-time tracking systems to monitor the transport process. These measures ensure that SMR units are secure and protected throughout their journey from potential threats.

By carefully considering these factors, regulatory frameworks can ensure that SMRs are deployed and operated in a secure fashion, such that they are protected against a range of potential risks and vulnerabilities.

VI. Conclusion

The integration of security-by-design principles into the regulatory framework for SMRs is crucial to ensure the secure deployment of this emerging technology. Additionally, a comprehensive approach to regulatory considerations, including state responsibilities, legal ownership, and transport security are essential for addressing associated risks and enhancing the overall security posture of SMRs. As the deployment of SMRs continues to advance, ongoing collaboration between international bodies, national regulators, and industry stakeholders will be vital in developing effective and adaptive security measures

Figure 1. Global Reactor Concepts[1]

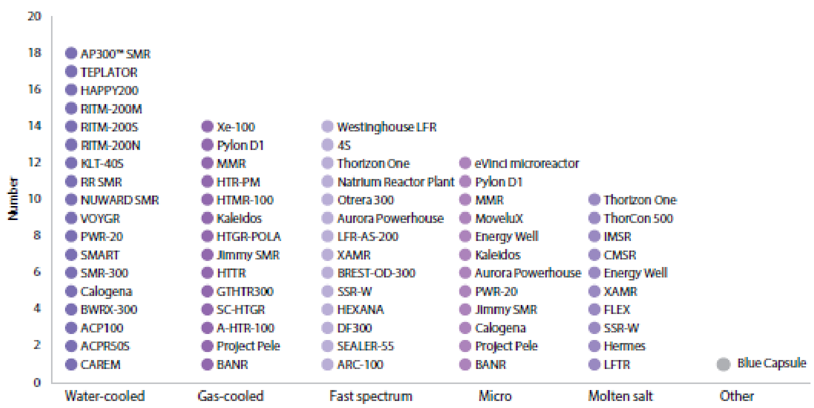


Figure 2. US NRC Licensing Options[2]

10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"	**10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants"**	**10 CFR Part 53**
- Construction Permit - Operating License - Limited Work Authorization - Site Suitability Reviews	- Early Site Permits - Standard Design Certification Combined License - Manufacturing License - Duplicate Plant License - Standard Design Approval - Site Suitability Reviews	Under Development

[1] NEA, "The NEA Small Modular Reactor Dashboard No.7650," Nuclear Energy Agency (NEA), Boulogne-Billancourt, 2023.

[2] "Sidley Austin LLP," 7 November 2024. [Online]. Available: https://www.sidley.com/en/insights/newsupdates/2024/11/us-nuclear-regulatory-commission-proposes-new-licensing-framework-for-advanced-reactors#:~:text=Part%2050%20(Part%2050)%20and,plants%20at%20a%20specific%20site.

NUCLEAR SPENT FUEL: TECHNOLOGY IS THERE FOR DISPOSAL, BUT U.S. LAW PREVENTS WASTE OPTIONS FROM MOVING FORWARD

Amy C. Roma, Stephanie Fishman, Cameron T. Hughes
Hogan Lovells US LLP
Washington, D.C.

I. Introduction

Nuclear energy is a reliable form of clean, firm energy, providing about 20 percent of power in the United States—and about 50 percent of the United States' low carbon power—with about 94 total reactors across 28 states.[1] In addition to the operating fleet, a number of new projects are planned around the country to provide power both to the grid and for industrial applications, such as chemical plants and data centers. In fact, the nuclear energy landscape is undergoing a significant transformation. In just late-2024 alone, tech giants Amazon, Microsoft, Google, and Meta announced gigawatts of planned new nuclear projects to support data centers[2]—with Amazon anchoring an equity investment of $500M in X-energy, an advanced reactor developer,[3] and announcing a book order for 5.5 GW of power; Microsoft entering into a power purchase agreement with Constellation for the restart of Three Mile Island, Unit 1;[4] Google announcing an agreement to build 500 MW with advanced nuclear developer, Kairos Power;[5] and Meta releasing a request for proposals to identify nuclear energy developers to help meet AI innovation and sustainability objectives.[6] These announcements follow the TerraPower advanced reactor project in Wyoming[7] and the X-energy advanced reactor project at a Dow Chemical plant in Texas,[8] which are both moving forward under the U.S. Department of Energy ("DOE") Advanced Reactor Demonstration Project.[9] On top of such private sector support, DOE announced a $900 million Request for Proposal to support new next-generation nuclear projects.[10] These trends demonstrate the

---

[1] U.S. Energy Information Administration (EIA), *FAQs*, updated May 8, 2024, available at https://www.eia.gov/tools/faqs/faq.php?id=207&t=3; U.S. Department of Energy (DOE), *5 Fast Facts About Nuclear Energy*, updated June 11, 2024, available at https://www.energy.gov/ne/articles/5-fast-facts-about-nuclear-energy#:~:text=Nuclear%20power%20provides%20nearly%20half,greenhouse%20gases%20while%20generating%20electricity.

[2] Hogan Lovells, *What's Really Going on with Data Centers and Nuclear?* (Dec. 6, 2024), available at https://www.hoganlovells.com/en/publications/whats-really-going-on-with-data-centers-and-nuclear.

[3] X-energy, *Amazon Invests in X-energy to Support Advanced Small Modular Nuclear Reactors and Expand Carbon-Free Power* (Oct. 2024), available at https://x-energy.com/media/news-releases/amazon-invests-in-x-energy-to-support-advanced-small-modular-nuclear-reactors-and-expand-carbon-free-power.

[4] Notably, Three Mile Island Unit 1 is big enough to power 800,000 homes. *See* Microsoft, *Accelerating the Addition of Carbo-Free Energy (*Sept. 2024), available at https://www.microsoft.com/en-us/microsoft-cloud/blog/2024/09/20/accelerating-the-addition-of-carbon-free-energy-an-update-on-progress/; Lucas Johnson, *Tech Companies and Their Love of Nuclear*, NUCLEAR ENERGY INSTITUTE (NEI), Oct. 22, 2024, available at https://www.nei.org/news/2024/tech-companies-and-their-love-of-nuclear.

[5] Nuclear Newswire, *Google and Kairos Power Partner on 500 MW Advanced Nuclear Project* (Oct. 2024) available at https://www.ans.org/news/article-6476/google-and-kairos-power-partner-on-500-mw-advanced-nuclear-project/.

[6] Meta, *Accelerating the Next Wave of Nuclear to Power AI Innovation* (Dec. 2024), available at https://sustainability.atmeta.com/blog/2024/12/03/accelerating-the-next-wave-of-nuclear-to-power-ai-innovation/ ; see also the Meta Request for Proposals, available at https://sustainability.atmeta.com/nuclear-energy-rfp-qualification-intake/.

[7] TerraPower, *TerraPower Begins Construction on Advanced Nuclear Project in Wyoming* (June 2024), available at https://www.terrapower.com/terrapower-begins-construction-in-wyoming.

[8] X-energy, Dow Chemical Partnership Timeline, available at https://x-energy.com/seadrift#:~:text=Dow%20and%20X%2Denergy%20plan,operations%20of%20the%20Seadrift%20Site.

[9] *See* DOE, Advanced Reactor Demonstration Program Website, available at https://www.energy.gov/ne/advanced-reactor-demonstration-program; Hogan Lovells, *Nuclear Energy As Key Technology For Energy Decarbonization and Energy Transition*, Feb. 21, 2024, available at https://www.lexology.com/library/detail.aspx?g=cb4dcd4a-9fe4-4bf8-8f55-ea14f1db5ec5.

[10] *Biden-Harris Administration Announces $900 Million to Build and Deploy Next-generation Nuclear Technologies*, U.S. DEP'T OF ENERGY, Oct. 16, 2024, available at

increasing importance of nuclear energy to meet U.S. energy needs.

Of all energy sources, nuclear energy has some of the lowest environmental impacts and highest safest records — attributes that many people do not realize. But despite an exceptional track record, nuclear energy continues to be hounded by misperceptions about what is it and how it interacts with the land and people around it. One of the recurring questions that comes up in any discussion about nuclear energy is "what about the waste?"

So what about it?

In a nutshell, the biggest "waste" consideration from nuclear energy is what to do with the nuclear fuel after it comes out of the reactor—what is called "spent fuel." Because nuclear energy is energy dense and highly efficient, the volumes of spent fuel generated are also very small compared to the power that comes out of it. Some commonly used comparison points for people new to the discussion include the following:

- One uranium pellet—which is roughly the size of a fingertip—can hold roughly the same amount of energy as one ton of coal, 149 gallons of oil, or 17,000 cubic feet of natural gas.[11]
- If an individual in the United States was to get 100% of their electricity from nuclear for their entire life, the resulting "spent fuel" could fit inside a soda can.[12]
- All the spent fuel and high level nuclear waste in the United States (going back about 80 years) could fit in a single football field, about 24 feet deep.[13]

Spent fuel retains about 95 percent of its energy after going through a reactor once,[14] meaning there is a ton of energy left in the fuel after its use in the reactor—but the United States does not recycle it, that is, turning the spent fuel back into new fuel. Instead, the spent fuel comes out of the reactor and is ultimately stored on a concrete pad in concrete canisters outside the reactor in a system called an Independent Spent Fuel Storage Installation Facility ("ISFSI"). At this point, that storage of spent fuel pretty much stays "as is" at the reactor site for the foreseeable future, which it can do safely.

Why? Is it because spent fuel is so complicated and dangerous that no one knows what to do with it? Is the path forward a scientific conundrum with human safety at risk? Nope, not at all. The nuclear industry already has in place the necessary technologies required for the final disposal of all of the waste it produces, and other countries have also developed permanent disposal pathways for their spent fuel.

Then why hasn't a spent fuel disposal option been implemented? It boils down to one simple primary answer: *U.S. law is preventing waste disposal pathways from moving forward*. That is, Spent fuel, and other high-level waste, is stored indefinitely at ISFSIs because of political inaction and a complicated set of decisions that promotes inertia instead of moving forward.

Therefore, the path forward on spent fuel and high-level waste is not a really technical issue but more a political one. In a nutshell, the spent fuel and high-level waste situation in the United States is the way it is because of a series of decisions and facts, which we summarize below:

- The U.S. government put in place a law in 1982, the Nuclear Waste Policy Act, that says the federal government will decide what to do with spent fuel and high-level waste. This law further stated that ultimately, such waste would be put in a deep geologic repository that DOE would own and operate and the U.S. Nuclear Regulatory Commission ("NRC") would license. The repository site selected by Congress in 1987 is at Yucca Mountain in Nevada.
- The Nuclear Waste Policy Act says the U.S. government will take title to the spent fuel from the utilities by 1998 (it's now 2025, so we are 27 years past that date), and will dispose of it in the geologic repository, a facility that was never licensed and remains unfunded by the U.S. government, not the

https://www.energy.gov/articles/biden-harris-administration-announces-900-million-build-and-deploy-next-generation-nuclear.

[11] NEI, *Nuclear Fuel*, available at https://www.nei.org/fundamentals/nuclear-fuel (last visited Dec. 11, 2024).

[12] World Nuclear Association (WNA), *Where Does Our Electricity Come From?*, available at https://world-nuclear.org/nuclear-essentials/where-does-our-electricity-come-from#:~:text=The%20power%20from%20one%20kilogram,fit%20inside%20a%20soda%20can (last visited Dec. 11, 2024).

[13] DOE, *The Ultimate Fast Facts Guide to Nuclear Energy*, Feb. 14, 2024, available at https://www.energy.gov/sites/prod/files/2019/01/f58/Ultimate%20Fast%20Facts%20Guide-PRINT.pdf.

[14] DOE, *8 Nuclear Energy Terms that Don't Mean What You Think*, Apr. 23, 2024, available at https://www.energy.gov/ne/articles/8-nuclear-energy-terms-dont-mean-what-you-think.

least of which is because people in Nevada don't seem to want it there.

- The U.S. government required utilities to enter into Standard Contracts with the government, under which the utilities paid both a one-time fee as well as one mill (1/10-cent) per kilowatt-hour of electricity they generate and sell into the Nuclear Waste Fund. This fund would pay for the costs associated with building the repository and disposing of the spent fuel from operating reactors.[15] So the nuclear plant operators would pay for the repository needed for the spent fuel and other high level waste generated at their nuclear power plants.
- However, when DOE did not take title to the nuclear waste by 1998, as set forth in law and under the Standard Contracts, the utilities—which had paid a large amount of money into the Nuclear Waste Fund—sued DOE for breach of contract and won. As a consequence, the U.S. taxpayers pay—in the form of court-awarded damages and settlement agreements between DOE and the utilities—to store spent fuel on that concrete pad outside the reactor, the ISFSI, indefinitely.[16]
- While DOE did prepare a license application for the Yucca Mountain Repository and submitted it to the NRC in 2008, Congress failed to continue to adequately fund the program. In March 2010, after announcing plans to terminate its proposal for Yucca Mountain, DOE submitted a motion to NRC to withdraw its application, and in September 2011, the NRC—in a controversial decision—formally suspended the adjudication.[17]
- Subsequently, in 2011, DOE was sued by a non-profit organization that represents state public service commissions that regulate utilities, and in a 2013 decision,[18] the U.S. Court of Appeals for the D.C. Circuit ordered the Secretary of the Department of Energy to suspend collecting annual fees for the Nuclear Waste Fund because DOE was failing to meet its statutory obligations under the Nuclear Waste Policy Act. In its decision, the court sharply criticized DOE's inconsistent position regarding Yucca Mountain as the site for a high-level radioactive waste repository.[19]

In sum, the Yucca Mountain Repository hasn't worked, but the law prevents other nuclear waste disposal facilities, and to some extent storage facilities, from moving forward. With the government paying for nuclear waste storage onsite, however, and with the very long lifespan of a nuclear power plant (and the Nuclear Waste Fund fees suspended), utilities had little incentive to push the government to figure out a solution forward here. The U.S. government also had little incentive to push things forward either, because spent fuel could safely be stored onsite at operating plants. These facts resulted in decades of inertia when it came to spent fuel and nuclear waste, with the result that many people stopped paying attention, lost the waste storyline, or forgot how we got here.

But wait—there's more:

- Let's not forget about that existing money in the Nuclear Waste Fund, which is supposed to fund all these activities. While there's more than $40 billion dollars in the Nuclear Waste Fund, that money went into the general U.S. Treasury, not a separate fund. So any proposed Congressional path forward would get "scored" by the Congressional Budget Office, a nonpartisan organization that evaluates the financial and budgetary impact of a proposal and how it would affect federal spending, revenue, and the deficit over a specific time period. A high score can make Congressional action more difficult potentially

[15] The Nuclear Waste Policy Act establishes a Nuclear Waste Fund to be used to pay for the disposition of commercial spent nuclear fuel and high-level radioactive waste. Section 302(a)(2) of the act establishes a fee of 1 mill (1/10-cent) per kilowatt-hour of electricity generated and sold.

[16] The U.S. government has determined that nuclear waste can be safely stored this way indefinitely, so there has been no pressing safety reason to move it. *See* NRC, *Independent Spent Fuel Facility Storage Installation Website*, available at https://www.nrc.gov/waste/spent-fuel-storage/isfsi.html.

[17] *See* Memorandum and Order (suspending Adjudicatory Proceeding), Atomic Safety and Licensing Board, Docket No. 63-001-HLW, ASLBP No. 09-892-HLW-CAB04, Sept. 30, 2011; GOVERNMENT ACCOUNTABILITY OFFICE (GAO), *Commercial Nuclear Waste: Resuming Licensing of the Yucca Mountain Repository Would Require Rebuilding Capacity at DOE and NRC, Among Other Key Steps*, Apr. 26, 2017, available at https://www.gao.gov/products/gao-17-340#:~:text=However%2C%20in%20March%202010%2C%20after,the%20Yucca%20Mountain%20licensing%20processhttps://www.gao.gov/products/gao-17-340#:~:text=However%2C%20in%20March%202010%2C%20after,the%20Yucca%20Mountain%20licensing%20process.

18 *See* National Association of Regulatory Utility Commissioners v. DOE, 736 F.3d 1585 (D.C. Cir. 2013).

[19] GAO, *supra* note 10.

reducing political support for the legislation.[20] Further, the fact that any spent fuel legislative path forward gets "scored" as requiring government spending, even though the funds have been paid by the U.S. nuclear industry into the Nuclear Waste Fund, chills action in Congress.

- Once Congress stopped meaningfully funding the Yucca Mountain project and the NRC license application was dismissed, no further major action has come from the federal government—who is in the driver's seat here for next steps. The only "action" in over a decade has been government reports—which kicks the can down the road (to another Administration and later Congress) to figure out what to do. The most notable of these reports was the "Blue Ribbon Commission on America's Nuclear Future," (the "Blue Ribbon Commission Report") a report issued in 2012 that was prepared by a Committee appointed by President Barack Obama to look into future options for existing and future nuclear waste, following the ending of work on the incomplete Yucca Mountain Repository.[21] The report summarized the issue of spent fuel and high-level waste as of 2012, as well as what other countries were doing, and made a number of recommendations for the development of a comprehensive strategy for managing spent fuel, including the creation of a dedicated, independent organization to handle and dispose of spent fuel and high-level waste, and the establishment of one or more permanent deep geological facilities for disposal of spent fuel and high-level waste, prioritizing a consent-based process for site selection.

- In addition to disposal, another option for spent fuel is to recycle it into new nuclear fuel. As mentioned, the United States does not recycle spent fuel. Initially, the United States planned to recycle spent fuel, with early efforts focused on developing reprocessing technologies. However, in 1976, President Gerald Ford issued an executive order halting commercial reprocessing and recycling of nuclear fuel due to proliferation concerns, specifically the risk of weapons-grade material being extracted during the process. This policy was later reinforced by President Carter, effectively ending domestic recycling efforts. Decades later, in 2006, President George W. Bush sought to revive interest in advanced reprocessing technologies, but the program faced funding and political challenges and was ultimately discontinued in 2009, leaving the U.S. without an active recycling program for spent nuclear fuel. In any event, with plenty of uranium available, the shift in government policy, spent fuel safely sitting onsite outside operating plants, and no one really paying too much attention to spent fuel storage and disposition matters, reprocessing and recycling activities did not move forward in United States. Many people still believe that spent fuel recycling is banned in the United States, either under law or policy, when it is not.

Ultimately, it was not until a few things happened that people started to think more seriously again about spent fuel and high-level waste. For one, nuclear power plants that have operated for decades started to retire, and people started to wonder about what to do with the spent fuel being quietly stored in the back yard on ISFSIs for these past few decades. At the same time, the interest in new plants increased and a number of new reactor projects are underway or planned. On top of that, DOE has amended the Standard Contracts to ensure the plant owner will pay for the storage of spent fuel until DOE is ready to pick it up. This confluence of factors has led people in the United States to meaningfully reengage and think about a path forward on spent fuel and high-level waste disposition. This is where we are now.

This paper weaves this holistic narrative together—making it a combined history, legal, and policy paper. Specifically, it explains:

- How nuclear energy is one of the safest forms of energy and has the least environmental impact—even including nuclear waste in the discussion;
- What spent fuel and high-level waste are—and that they are not as scary as people often think;
- The high level history of nuclear waste policy management in the United States, including an explanation of the Nuclear Waste Policy Act, the Yucca Mountain Repository conundrum, and the Blue Ribbon Commission Report exploring paths forward;
- Looking at what other countries do, including storage, disposal, and reprocessing and recycling;
- Current and potential spent fuel storage in the United States;

[20] Committee for a Responsible Federal Budget, *A Short Primer on the Congressional Budget Office*, Feb. 14, 2018, available at https://www.crfb.org/blogs/short-primer-congressional-budget-office#whyiscboimportant.

[21] BLUE RIBBON COMMISSION ON AMERICA'S NUCLEAR FUTURE, *Report to the Secretary of Energy* (2012), available at https://www.energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf [hereinafter "BRC Report"].

- Reprocessing and recycling spent fuel in the United States; and
- Weaving it all together to explain where this leaves us.

Ultimately, something needs to be done to enable a path forward for the storage, reuse, and final disposal of spent nuclear fuel and high-level waste. Only by understanding the technical considerations overlaid with the historical, legal and policy issues, can we work toward a path forward that solves this impasse.

II. Nuclear energy is one of the safest forms of energy with low environmental impacts

Nuclear power has a safety record and environmental impact that are often misunderstood—and grossly overinflated—which is why we start this paper with a discussion about the extraordinary safety record, and minimum environmental impact of nuclear energy, even taking into account its waste.[22]

a. Nuclear energy is widely regarded as one of the safest energy sources

Nuclear energy has an extraordinary safety record, with 440 plants operating around the world and 70+ years of operational history since nuclear energy first brought electrons to the grid. A few high-profile incidents have created public concerns, though many of them have been sensationalized by the media and others to create a misperception about the dangers of nuclear energy. Looking at the numbers, statistically speaking, nuclear energy results in fewer fatalities per unit of electricity generated compared to traditional energy sources and is on par with the safety record of wind and solar.[23] In fact, whenever fuels (coal, oil, gas, and biomass) are replaced with nuclear, lives are saved and emissions decrease.[24]

b. Nuclear energy is less impactful on the environment than other power sources

Additionally, nuclear energy is less impactful on the environment than other energy sources, including renewables. Unlike wind and solar, which depend on vast land use and mining for materials like rare earth metals, nuclear power generates massive amounts of energy from a small footprint with minimal environmental disruption. It also operates consistently, avoiding reliability issues linked to weather-dependent renewables. According to a UN Economic Commission for Europe report entitled "Life Cycle Assessment of Electricity Generation Options," which analyzed the safety and environmental profiles of the full lifecycle of energy sources to evaluate their "all in" costs—such as greenhouse gas emissions, human toxicity, water use, and other health metrics of different electricity sources—among wind, solar, coal, gas, hydro, and nuclear, the report concluded that nuclear had some of the smallest impacts out of all the electricity sources.[25]

Nuclear also utilizes resource efficiently, using a small amount of fuel to produce a significant amount of electricity, making it a highly efficient energy source. Specifically, a typical 1,000-megawatt nuclear facility in

---

[22] WNA, *Safety of Nuclear Power Reactors*, updated Aug. 23, 2024, available at https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors https://ourworldindata.org/safest-sources-of-energy#:~:text=Nuclear%20energy%2C%20for%20example%2C%20results,and%2097.6%25%20fewer%20than%20gas; Jack Unwin, *Nuclear Power: The Pros and Cons of the Energy Source*, POWER TECHNOLOGY, May 28, 2019, available at https://www.power-technology.com/features/nuclear-power-pros-cons/.

[23] For example, nuclear energy results in fewer deaths than coal; fewer than oil; and fewer than gas. *See* TerraPraxis, *Beautiful Nuclear*, available at https://www.terrapraxis.org/projects/beautiful-nuclear; *see also* Our World in Data: Nuclear Energy (2020), available at https://ourworldindata.org/safest-sources-of-energy. Notably, modern nuclear reactors are equipped with multiple layers of safety systems designed to prevent accidents and mitigate potential risks. *Id.* Note, in the U.S., the most significant nuclear incident was the Three Mile Island accident in Harrisburg, Pennsylvania, in 1978. There were no reported injuries or direct health effects from the incident. *See* Nuclear Regulatory Commission, *Backgrounder on the Three Mile Island Incident*, updated Mar. 28, 2024, available at https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.

[24] *See* TerraPraxis, *Beautiful Nuclear*, available at https://www.terrapraxis.org/projects/beautiful-nuclear.

[25] UN Economic Commission for Europe, *Carbon Neutrality in the UNECE Region: Life Cycle Assessment of Electricity Sources*, March 2022, available at https://unece.org/sites/default/files/2022-04/LCA_3_FINAL%20March%202022.pdf; EIA, *Nuclear Explained: Nuclear Power and the Environment*, updated Nov. 7, 2022, available at https://www.eia.gov/energyexplained/nuclear/nuclear-power-and-the-environment.php#:~:text=Unlike%20fossil%20fuel%2Dfired%20power,or%20carbon%20dioxide%20while%20operating; DOE, *3 Reasons Why Nuclear is Clean and Sustainable*, Mar. 31, 2021, available at https://www.energy.gov/ne/articles/3-reasons-why-nuclear-clean-and-sustainable.

the United States needs a little more than 1 square mile to operate, whereas a wind farms require 360 times more land area to produce the same amount of electricity and solar photovoltaic plants require 75 times more space.[26]

Nuclear power has the highest capacity factor[27] of any electricity source at 93%, about twice as much as natural gas and three times more than solar and wind.[28] Capacity factor is how much energy a power plant actually produces compared to its "nameplate" or on-paper capacity—essentially a measure of how reliable a plant is. This high capacity factor means that replacing a single one-gigawatt nuclear reactor with an energy alternative, in practice, would need about two gigawatts of natural gas plants or three gigawatts of wind turbines—about 1,300 utility-scale wind turbines.[29]

Ultimately, nuclear energy presents a compelling case as a safe and environmentally friendly energy source. Its high safety rating and minimal environmental impact position it as a valuable tool in the fight against climate change and the pursuit of sustainable energy solutions. With that background, let's turn to the waste discussion.

III. The nuclear fuel cycle—what is spent fuel and where does it come from?

The nuclear fuel cycle is an essential process for ensuring the long-term viability of nuclear energy—and the energy security and independence nuclear energy provides. It consists of a series of processes that encompass the production, use, and management of nuclear fuel. The fuel cycle begins with the mining of uranium ore, which is then processed and enriched to create fuel for nuclear reactors. Then, once the fuel has been utilized in a reactor, nuclear energy is generated while producing spent fuel, which requires careful handling and storage due to its radioactive nature.[30] This overview explores each stage of the nuclear fuel cycle, highlighting the technological, environmental, and safety considerations that shape its development and implementation in the quest for sustainable energy solutions.

a. Overview of the fuel cycle

Generally, the nuclear fuel cycle is made up of two phases: the front end and the back end. The front end prepares uranium for use in nuclear reactors. These steps include mining, milling, conversion, enrichment, and fuel fabrication. The back end ensures that the used nuclear fuel is safely managed, recycled, or disposed of. These steps include fuel storage, recycling, and waste disposal.

More specifically, on the front-end of the nuclear fuel cycle, the process begins with uranium mining, where uranium ore is extracted from the earth using methods such as open-pit mining, underground mining, or in-situ leaching. Once mined, the ore undergoes milling, a process that concentrates the uranium into a powder known as "yellowcake" (uranium oxide). The uranium oxide is then subjected to conversion, where it is chemically transformed into uranium hexafluoride (UF6) gas, a form suitable for enrichment. During enrichment, the UF6 gas is processed to increase the concentration of the fissile uranium isotope U-235 through various techniques. The enriched uranium is then used in fuel fabrication. Currently, the fuel used in the U.S. converts the uranium into small pellets, packed into rows in fuel rods, which are subsequently assembled into fuel assemblies for placement in the reactor. In the reactor operation phase, these fuel assemblies are loaded into the reactor core, where nuclear fission reactions take place, generating heat. This heat is transferred in the heat

[26] DOE, *supra* note 6; Emma Derr, *Nuclear Needs Small Amounts of Land to Deliver Big Amounts of Electricity*, NEI, Apr. 29, 2022, available at https://www.nei.org/news/2022/nuclear-brings-more-electricity-with-less-land.

[27] DOE, *Nuclear Power is the Most Reliable Energy Source and It's Not Even Close*, Mar. 24, 2021, available at https://www.energy.gov/ne/articles/nuclear-power-most-reliable-energy-source-and-its-not-even-close.

[28] EIA, *Electric Power Monthly: Table 6.07.B Capacity Factors for Utility Scale Generators Primarily Using Non-Fossil Fuels*, available at https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b (last visited Dec. 11, 2024).

[29] DOE, *INFOGRAPHIC: How Much Power Does a Nuclear Reactor Produce?*, Mar. 31, 2021, available at https://www.energy.gov/ne/articles/infographic-how-much-power-does-nuclear-reactor-produce.

[30] DOE, *Nuclear Fuel Cycle*, available at https://www.energy.gov/ne/nuclear-fuel-cycle#:~:text=The%20nuclear%20fuel%20cycle%20is,%2C%20recycled%2C%20or%20disposed%20of (last visited Dec. 11, 2024); WNA, *Nuclear Fuel Cycle Overview*, updated May 20, 2024, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview#:~:text=The%20various%20activities%20associated%20with,end'%20of%20the%20fuel%20cycle; INTERNATIONAL ATOMIC ENERGY ASSOCIATION (IAEA), *Getting to the Core of the Nuclear Fuel Cycle: From the Mining of Uranium to the Disposal of Nuclear Waste* (2012), available at https://www.iaea.org/sites/default/files/18/10/nuclearfuelcycle.pdf.

transfer step, where it is used to produce steam, which drives a turbine to generate electricity.

On the back-end of the nuclear fuel cycle, the process begins with the spent fuel being taken out of the reactor core. More specifically, after nuclear fuel has been used in a reactor, it goes into spent fuel storage, where the used fuel assemblies are temporarily stored in cooling pools or dry casks to allow for radiation levels to decrease and the fuel to cool. In some cases—all outside the United States—reprocessing and recycling the spent fuel into new fuel for use in reactors may follow, a process in which reusable uranium and plutonium are chemically separated from the spent fuel for potential recycling and further use in reactors. The byproduct of this reprocessing is high-level waste, which must be stored in a repository.

At present in the United States, all spent fuel and other forms of high-level waste—not just the products that cannot be reprocessed—are intended for disposal in deep geological repositories designed to isolate them from the environment for thousands of years.[31] In the meantime, spent fuel is stored onsite at nuclear power plants in ISFSIs, which are essentially a concrete pad with casks stored on top. There are currently more than 60 ISFSIs across the United States, located adjacent to nuclear power plants, decommissioning nuclear power plants, or in some cases, former nuclear power plant sites that have been entirely decommissioned.[32] Also at present there are about 263,000 tonnes of used fuel in storage.[33] A number of companies have sought and received NRC licenses for "Consolidated Independent Storage" or "CIS" facilities, which is an away-from-reactor ISFSI, but none of these CIS facilities have been built, as explained further below.

b. Spent fuel and high-level waste

Notably, spent fuel is only considered to be waste if there is no further use for it. If the spent fuel is reprocessed and recycled into new fuel, then ultimately, the waste discussion changes considerably compared to disposing spent fuel that has only gone through a reactor once.

By way of background, radioactive waste includes any material that is either itself radioactive or has been contaminated by radioactivity, and that is deemed to have no further use. Every radionuclide has a half-life—the time taken for half of its atoms to decay, and thus for it to lose half of its radioactivity. Radionuclides with long half-lives tend to be alpha and beta emitters—making their handling easier—while those with short half-lives tend to emit the more penetrating gamma rays. Eventually all radioactive waste decays into non-radioactive elements. The more radioactive an isotope is, the faster it decays. Radioactive waste is typically classified as either low-level, intermediate-level waste, or high-level waste (sometimes abbreviated as "HLW"), dependent, primarily, on its level of radioactivity. Within a period of 1,000-10,000 years, the radioactivity of HLW decays to that of the originally mined ore. Its hazard then depends on how concentrated it is.[34]

The amount of so-called waste produced by the nuclear power industry is small relative to the waste produced by other industrial activities.[35] Further, the overwhelming volume of radioactive waste produced at a nuclear power plant can be disposed of as low level

[31] WNA, *Radioactive Waste – Myths and Realities*, updated Aug. 12, 2024, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-wastes-myths-and-realities; NATIONAL ACADEMIES, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, (2006), available at https://nap.nationalacademies.org/read/11263/chapter/14#:~:text=TABLE%201.1%20provides%20a%20listing,under%20the%20power%20reactor%20license.

[32] Note, this number includes site specific licensed ISFSIs as well as generally licensed ISFSIs. *See* NRC, *U.S. Independent Spent Fuel Storage Installations (ISFSI)*, Apr. 22, 2021, available at https://www.nrc.gov/docs/ML2111/ML21116A041.pdf; NRC, *NRC Maps of Independent Spent Fuel Storage Installations (ISFSI)*, updated Nov. 8, 2021, available at https://www.nrc.gov/reading-rm/doc-collections/maps/isfsi.html.

[33] WNA, *Radioactive Waste Management*, updated Jan. 25, 2022, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-waste-management#:~:text=The%20more%20radioactive%20an%20isotope,on%20its%20level%20of%20radioactivity.

[34] By comparison, other industrial wastes (such as heavy metals like cadmium and mercury) remain hazardous indefinitely. *See* WNA, Radioactive Waste—Myths and Realities (Aug. 2024), available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-wastes-myths-and-realities.

[35] WNA, *Radioactive Waste – Myths and Realities*, updated Aug. 12, 2024, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-wastes-myths-and-realities.

radioactive waste.[36] The remaining volume of waste, is high-level waste, such as spent fuel that has been designated as waste; and separated waste from reprocessing of spent fuel.

The amount of high-level waste produced during nuclear production (including used fuel, when this is considered as waste) is small; a typical large reactor of one gigawatt electricity produces about 25-30 tonnes of used fuel per year.[37] About 400,000 tonnes of used fuel have been discharged from reactors worldwide, with about one-third having been reprocessed.[38]

Currently, interim storage facilities effectively contain and manage existing waste, and the gradual decline of heat and radioactivity over time supports the practice of storing HLW temporarily before final disposal.[39] In fact, after 40 years, the radioactivity of used fuel has generally decreased to about one-thousandth of the level at the point when it was unloaded from the reactor.[40]

In the long-term, however, appropriate disposal arrangements are required for HLW due to its prolonged radioactivity. The safe, environmentally-sound disposal of HLW is technologically proven, with international scientific consensus on deep geological repositories. Such projects are well advanced in some countries, such as Finland and Sweden. In the United States, a deep geological waste repository, the Waste Isolation Pilot Plant, is already in operation for the disposal of transuranic waste, which is long-lived intermediate-level waste contaminated with military materials such as plutonium.

IV. History of nuclear waste management policy in the United States

How this spent fuel and high-level waste has been disposed of—and what the United States government has decided to do with it—has been shaped by the challenges of changed U.S. government priorities and positions over the years. Early nuclear programs in the mid-20th century prioritized weapons development and energy production, with limited planning for long-term waste management. The 1982 Nuclear Waste Policy Act ("NWPA") marked a pivotal step, mandating a comprehensive federal strategy for high-level radioactive waste disposal, including the identification and development of a geologic repository. Yucca Mountain in Nevada was designated by Congress as the sole candidate site in 1987, but political opposition and safety concerns stalled its progress. The federal government has since struggled to implement a permanent solution, relying on interim storage and leaving utilities and states uncertain about long-term waste management. Efforts to revisit nuclear waste policy continue, reflecting the ongoing tension between technological challenges, public opposition, and political will.

We walk through these issues in further detail below.

a. Beginning of the nuclear industry until 1982

Before the NWPA, U.S. government attention to spent fuel and high-level waste management was largely focused on the defense program because of the pressing need to handle the byproducts of nuclear weapons production during the Cold War. The Manhattan Project and subsequent defense initiatives prioritized the development and deployment of nuclear weapons, resulting in significant quantities of high-level radioactive waste. Managing this waste was vital for national security and environmental safety near defense production facilities. Civilian nuclear power generation, though emerging in the 1950s, was secondary in priority. The lack of a comprehensive policy framework led to ad hoc solutions, such as temporary storage at reactor sites and defense facilities, rather than a coordinated, long-term strategy for waste disposal. The NWPA was enacted later to address the growing need for a unified approach to both civilian and defense-related nuclear waste.

In one of the first serious efforts to thing about long-term nuclear waste management solutions, in 1957 National Academy of Sciences published a report entitled *The Disposal of Radioactive Waste on Land*. The authors of the report concluded that "radioactive waste can be disposed of safely in a variety of ways and at a large number of sites in the United States," but that the "most promising method of disposal of high-level waste at the present time seems to be in salt deposits."[41] The report

[36] *Id.,* WNA, *Radioactive Waste Management*, updated Jan. 25, 2022, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-waste-management.
[37] *See* WNA, Radioactive Waste—Myths and Realities (Aug. 2024), available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-wastes-myths-and-realities.
[38] *Id*.
[39] EPRI Report, *Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility* (2008).
[40] IAEA, *Getting to the Core of the Nuclear Fuel Cycle* (last visited Dec. 13, 2024), available at https://www.iaea.org/sites/default/files/18/10/nuclearfuelcycle.pdf.
[41] NATIONAL ACADEMY OF SCIENCES, THE DISPOSAL OF RADIOACTIVE WASTE ON LAND 3-4 (1957).

urged investigation of the ideal geologic sites around the country to which high-level waste could be safely and economically transported.[42]

The Atomic Energy Commission ("AEC")—the original nuclear regulatory agency in the United States—therefore began searching for possible geologic disposal options and potential salt bed repository sites.[43] Concurrently, the national laboratories at Oak Ridge, Los Alamos, Argonne, and others began researching how to handle and treat high-level radioactive waste.[44] Through the 1960s and 1970s the AEC and the Energy Research and Development Administration—the AEC's then-successor agency responsible for nuclear waste—investigated potential salt mines and salt beds in Kansas, Michigan, Texas, Utah, Washington, and elsewhere. Among these sites were an area of salt beds near Carlsbad, New Mexico, which became the Waste Isolation Pilot Plant for defense-related transuranic radioactive waste, and a section of welded volcanic tuff at Yucca Mountain in Nevada.[45] However, by the late 1970s, no site for long-term storage of high-level radioactive waste had been selected, and yet the commercial nuclear industry in the country, and therefore the quantity of spent fuel and high-level waste, had grown considerably.

b. U.S. policy under the Nuclear Waste Policy Act of 1982

Congress passed the NWPA to address the growing challenge of managing the United States' high-level waste and spent fuel from defense programs and civilian nuclear power plants. By the early 1980s, temporary storage solutions at nuclear reactor sites were nearing capacity, and there was no clear federal strategy for long-term waste disposal, raising environmental, safety, and political concerns. The NWPA established a comprehensive framework to ensure the safe, permanent disposal of nuclear waste, tasking DOE with developing a geologic repository and setting a timetable and process for site selection.[46] The act required nuclear utilities to fund the effort through the Nuclear Waste Fund and mandated public engagement and environmental assessments. Congress therefore passed the NWPA to ensure federal leadership in resolving the waste management issue, enhance public and environmental safety, and sustain confidence in nuclear energy as a viable energy source. The act also makes it the federal government's responsibility to provide a place for the permanent disposal of high-level waste but provided that the cost of such disposal would be the responsibility of nuclear facility owners.[47]

Under the NWPA, some of the key provisions that have been the most impactful on current policy include the following:

- **U.S. government would establish a repository**. The NWPA provided a means for the federal government to select appropriate sites for a permanent geologic repository.[48] The Secretary of Energy, with appropriate consultation, would identify potential sites for spent fuel and high-level waste repositories, subject to limitations on nearby population and appropriate hydrology, geophysics, and water resources.[49] Then, after consulting with the state governors of the possible sites, the Secretary would recommend to the President at least five sites for an initial repository.[50] Each site under consideration by the Secretary would be subject to public hearings in the vicinity of each site.[51] Interestingly, the storage of such waste was originally to be distributed among multiple sites—the President was to officially recommend to Congress an initial repository site by 1987 and a second repository site in 1990.[52] If the governor or legislature of the host state, or the governing body of an affected Indian tribe, disapproved of a selected site, then the president was obliged to recommend a different site to Congress.[53] The NWPA further stated that once DOE applied for a

[42] *Id.* at 4.
[43] BRC Report, *supra* note 13 at 20; JOINT COMM. ON ATOMIC ENERGY, 86TH CONG., INDUSTRIAL RADIOACTIVE WASTE DISPOSAL 32-33 (Joint Comm. Print 1959) available at https://www.nrc.gov/docs/ml1209/ML120960603.pdf.
[44] JOINT COMM. ON ATOMIC ENERGY, *supra* note 36 at 24.
[45] BRC Report, *supra* note 13 at 20; *see also* Waste Isolation Pilot Plant, available at https://www.wipp.energy.gov/ (last visited Dec. 11, 2024).
[46] *See generally*, Nuclear Waste Policy Act of 1982.
[47] NWPA Sec. 111(a)(4).
[48] While it is technically arduous and politically challenging to develop a permanent geologic repository, some storage and disposal will likely always be needed for the most radioactive components of spent nuclear fuel, even if such fuel is first reprocessed and recycled. *See also BRC Report*, *supra* note 13 at 28. As set forth in the BRC Report, the ideal site would be isolated, but with the ability to retrieve waste and/or reverse course on policy before the repository is permanently closed. *See* 10 CFR 60.111(b); *BRC Report*, *supra* note 13 at 20-21.
[49] NWPA Sec. 112(a).
[50] *Id*. at Sec. 112(b).
[51] *Id*. at Sec. 114(a)(1).
[52] *Id*. at Sec. 114(a)(2)(A).
[53] *Id*. at Sec. 114(a)(3).

construction authorization for a repository, the NRC would consider the application.[54]

Pursuant to the NWPA, in May 1986, the Secretary of Energy recommended three potential sites for the initial repository: Hanford in Washington state, Deaf Smith County in Texas, and Yucca Mountain in Nevada. By then, however, the political situation for high-level waste storage was worsening—elected officials from all states with sites under consideration were building opposition to the permanent storage of nuclear waste in their states. Given the increasing tensions, as well as rising costs and lower projections for future nuclear waste production, the U.S. government made two decisions: first, the Secretary of Energy suspended the search for a second repository; and second, Congress amended the NWPA in 1987 to designate Yucca Mountain in Nevada as the sole site for a permanent geologic repository.[55]

- **Establishment of the Nuclear Waste Fund.** To pay for this eventual disposal, the NWPA authorized DOE to enter into contracts with utilities—later called a Standard Contract—under which DOE would remove spent fuel from reactor sites beginning in 1998 and take title to it upon receipt. In exchange, utilities would pay the costs of developing, operating, and maintaining facilities for spent fuel disposal, including the proposed geologic repository at Yucca Mountain.[56] Utilities that generate electricity from nuclear power plants are required to pay a fee of 1 mill (0.1 cent) per kilowatt-hour of nuclear-generated electricity sold. Utilities are also required to pay a so-called "one-time fee," an additional charge that nuclear utilities are required to pay as part of the Standard Contract with the DOE.

  This fee, separate from the ongoing per-kilowatt-hour fee of 1 mill (0.1 cent), is designed to cover the initial costs of the federal government's efforts to begin managing and disposing of high-level waste and spent nuclear fuel. The fee amount is determined by DOE and typically reflects a utility's contribution toward covering the long-term disposal costs associated with spent fuel already generated at the time the contract is signed. These fees, along with the interest earned on the fund's investments in U.S. Treasury securities, make up the majority of the Nuclear Waste Fund's revenue. By now the fund has accrued substantial revenue; today it has a balance of approximately $50.4 billion.[57]

- **Standard Contract.** The NWPA required DOE to establish Standard Contracts with nuclear utilities to provide for the disposal of spent nuclear fuel and high-level waste. These contracts, mandated under Section 302 of the NWPA, required utilities to pay fees into the Nuclear Waste Fund to finance the development of a geologic repository. In return, the DOE was obligated to begin accepting waste for disposal by January 31, 1998, following a priority schedule based on waste generation dates. Codified under 10 CFR Part 961, the contracts established a framework for DOE's responsibility to transport and dispose of spent nuclear fuel while utilities prepared the waste for transfer. The NRC was prohibited from issuing a new reactor license unless the licensee signed a Standard Contract with DOE.[58] Key provisions of the Standard Contract include:
  - **DOE responsibility:** The DOE is responsible for accepting, transporting, and disposing of the waste at a federally designated repository.
  - **Utility responsibility**: Utilities must package and prepare waste for transfer to the DOE and continue making payments into the Nuclear Waste Fund.
  - **Timeline for waste acceptance**: Initially, the DOE was required to begin accepting waste by 1998, a deadline it failed to meet, leading to lawsuits and significant financial liabilities.
  - **Priority ranking**: Waste acceptance follows a priority ranking system based on when the waste was generated.

- **Limits on DOE's ability to build Consolidated Interim Storage facilities.** A CIS facility would offer an away-from-reactor place for spent fuel storage, providing a stable solution until a permanent repository or disposal site becomes available While the U.S. government can build a CIS facility before establishing a geologic repository, the NWPA is structured in such a way that doing so requires legislative and regulatory alignment.[59] The NWPA of

[54] *Id*. at Sec. 114(d).
[55] BRC Report, *supra* note 13 at 22; H.R. 3025, "Nuclear Waste Policy Amendments Act" (1987).
[56] NWPA Sec. 123.
[57] DOE, *Audit Report: The Department of Energy Nuclear Waste Fund's Fiscal Year 2024 Financial Statement Audit*, Nov. 2024, available at https://www.energy.gov/sites/default/files/2024-11/DOE-OIG-25-03.pdf.
[58] NWPA Sec. 302(b).
[59] *See generally* NWPA Subtitle B.

1982 originally focused on the development of a permanent geologic repository for high-level nuclear waste. The act also allowed for interim storage, but it tied the development of CIS facilities to progress on a permanent repository, effectively making the repository a priority.[60] This connection has historically limited the federal government's ability to construct interim storage without substantial progress on a repository like Yucca Mountain. To allow the federal government to build a CIS facility independently, Congress would need to amend the NWPA or enact new legislation to provide explicit authority for such a project. Legislative proposals have occasionally aimed to decouple interim storage from the repository requirement to address the growing need for centralized waste management.[61]

After the NWPA, and when DOE moved forward on Yucca Mountain, including preparing and submitting an NRC license application, utilities entered into the Standard Contract and began to pay their fees into the Nuclear Waste Fund.

c. But then it all went sideways — what happened and why?

The Yucca Mountain project, originally designated as the United States' primary geologic repository for high-level radioactive waste under the NWPA, has faced significant political, environmental, and technical challenges, leading to its stalling. Despite years of research and investment, the project has been repeatedly delayed due to opposition from Nevada lawmakers, and funding issues. In 2009, the Obama administration effectively halted the project by withdrawing its NRC application for a license to build the facility,[62] despite DOE having signed Standard Contracts with nuclear utilities to begin waste disposal in 1998.[63] This decision alongside DOE's failure to meet the Standard Contract obligation to accept spent fuel by the stipulated date, led to lawsuits from utilities alleging breach of contract. The utilities argued that the DOE's failure to begin spent fuel acceptance as promised resulted in additional costs and liabilities for long-term storage at their sites. As of September 2024, DOE had paid approximately $11.1 billion in damages for its breach, marking a significant failure of the federal commitment under the NWPA and underscoring the ongoing dispute over nuclear waste management in the United States.[64]

1. Failed experience with the Yucca Mountain Repository program

A keystone in the story of the Unites States' struggles with spent fuel policy is the country's sole attempt at developing a permanent geologic repository: Yucca Mountain. As mandated by the 1987 amendments to the NWPA, discussed above, DOE considered Yucca Mountain as the only site for a permanent geologic repository. In 2002, four years *after* the NWPA required it to start accepting waste for disposal, the Secretary of Energy recommended to the president that Yucca Mountain be approved as the sole geologic repository for spent nuclear fuel and high-level waste, and no other site be evaluated a originally envisioned, concluding that Yucca Mountain was "scientifically and technically suitable for the development of a repository," a conclusion backed up by over twenty years of investigations of Yucca Mountain's geologic features and other characteristics.[65] DOE subsequently filed a license application for a high-level waste repository at Yucca Mountain with the NRC in 2008.[66]

The NRC had an unprecedented runway—21 years—to prepare to review DOE's Yucca Mountain application—with the passage of the NWPA in 1982, the selection of the Yucca Mountain site by Congress in 1987, and the NRC application submission in 2008. That

[60] *See* NWPA Sec. 135.

[61] *See, e.g.*, H.R. 10227, 118th Cong. (2024) (Storage and Transportation of Residual and Excess Nuclear Fuel Act of 2024).

[62] While the Obama Administration halted funding for the project, it moved to withdraw the application on March 3, 2010. *See* Congressional Research Services (CRS), *Civilian Nuclear Waste Disposal* (updated Sept. 2019), available at https://crsreports.congress.gov/product/pdf/RL/RL33461/54.

[63] *Id.*, *see also* Congressional Research Services (CRS), *Civilian Nuclear Waste Disposal* (updated May 2018), available at https://crsreports.congress.gov/product/pdf/RL/RL33461/51#:~:text=DOE%20had%20submitted%20a%20license%20application%20for,withdraw%20the%20application%20on%20March%203%2C%202010.

[64] DOE, *supra* note 50 at 27.

[65] Office of Civilian and Radioactive Waste Management, Nuclear Waste Repository Program: Yucca Mountain Site Recommendation to the President and Availability of Supporting Documents, 67 Fed. Reg. 9,048 (Feb. 27, 2002).

[66] NRC, *DOE's License Application for a High-Level Waste Geologic Repository at Yucca Mountain*, updated Feb. 12, 2018, available at https://www.nrc.gov/waste/hlw-disposal/yucca-lic-app.html.

unprecedented foresight led the NRC to undertake massive technical, regulatory, and adjudicatory preparations in order to review DOE's application when it was submitted.[67]

The NRC already had a licensing pathway for disposal of high-level waste in a geologic repository, which it promulgated in 1981, before the passage of the NWPA, which was amended frequently thereafter.[68] Once DOE submitted its application, the NRC staff kicked into full gear to review the application under its regulations, scrutinizing both the environmental and safety characteristics of the proposed facility. The NRC staff proposed to adopt DOE's Environmental Impact Statement, except for a need to study additional groundwater effects.[69] For the safety review, the NRC used contractors who were experts in geochemistry, hydrology, structural geology, volcanology, seismology, and health physics, among others, as well as several professions of engineering.[70] The NRC staff ultimately determined that the Commission should not authorize construction until DOE met certain land and water rights requirements, but that otherwise the site was technically sound for long-term storage of nuclear waste.[71]

Despite the money and effort that had gone into the Yucca Mountain Repository review, the Obama administration in 2009 reversed course away from the existing U.S. policy on disposal, largely due to political opposition from Nevada and others.[72] DOE filed a motion with the NRC on March 3, 2010, to withdraw its licensing application "with prejudice," meaning it could not be resubmitted in the future. DOE stated that it was not seeking to withdraw the application for scientific or technical reasons, but rather because "the Secretary of Energy has decided that a geologic repository at Yucca Mountain is not a workable option for long-term disposition of these materials."[73]

Congress put the final nail in the coffin for the Yucca Mountain application, when it stopped funding the NRC's review of the application in 2011, upon request from the Obama administration. DOE consequently shut down its Yucca Mountain Repository program at the end of 2010.[74]

The NRC used what remained of its Yucca Mountain Repository appropriations from prior years to issue the final two volumes in its five-volume Safety Evaluation Report, complete a supplemental Environmental Impact Statement on the groundwater issue, and make the Web-Based Licensing Support Network it

---

[67] For example, the NRC prepared for the expected administrative adjudication by building an online e-discovery system out of whole cloth, which included over 3.6 million documents by the time DOE submitted its application. *See* NRC, *Backgrounder on Licensing Yucca Mountain*, updated Oct. 31, 2024, available at https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/yucca-license-review.html. The NRC also built a hearing facility in Las Vegas, consistent with the NRC policy that licensing board evidentiary hearings should be conducted in the vicinity of the proposed facility. *See, e.g.*, NRC, *Information Guide for Atomic Safety and Licensing Board Proceedings at the NRC Las Vegas Hearing Facility*, Mar. 2009,available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0336/br0336r1.pdf.

[68] The Nuclear Waste Policy Act has been amended several times, including in 1987 and in2019. *See, e.g.*, H.R. 2699 - Nuclear Waste Policy Amendments Act of 2019; H.R. 2967 - Nuclear Waste Policy Amendments Act of 1987. Examples of amendments included establishing the Nuclear Waste Policy Review Commission to advise Congress on the safe disposal of radioactive waste, directing DOE to temporarily store commercial spent nuclear fuel, and updating the Nuclear Regulatory Commission licensing process.

[69] NRC, *U.S. Nuclear Regulatory Commission Staff's Adoption Determination Report for the U.S. Department of Energy's Environmental Impact Statements for the Proposed Geologic Repository at Yucca Mountain*, Sept. 5, 2008, available at https://www.nrc.gov/docs/ML0824/ML082420342.pdf.

[70] NRC, *Backgrounder on Licensing Yucca Mountain*, updated Oct. 31, 2024, available at https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/yucca-license-review.html.

[71] NRC, *Safety Evaluation Report (SR-1949)* (2010-2015), available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1949/index.html ; *see* NRC, *NRC Publishes Final Two Volumes of Yucca Mountain Safety Evaluation*, Jan. 29, 2015, available at https://www.nrc.gov/docs/ML1502/ML15029A543.pdf

[72] While the Obama Administration halted funding for the project, it moved to withdraw the application on March 3, 2010. *See* Congressional Research Service (CRS), *Civilian Nuclear Waste Disposal* 12 (2021), updated Sept. 17, 2024, available at https://crsreports.congress.gov/product/pdf/RL/RL33461.

[73] U.S. Department of Energy's Motion to Withdraw at 1 (Mar. 3, 2010), https://www.nrc.gov/docs/ML1006/ML100621397.pdf

[74] *Id.* at 5; *see also* Pub. L. No. 112-10 (2011) (providing no appropriations for Yucca Mountain).

had created for adjudication available to the public.[75] However, it lacked the funding to otherwise complete the licensing process—including the final determination from the Commission that would grant or deny DOE a license for the Yucca Mountain Repository. The NRC estimated, however, that it would need an additional $330 million to finish licensing DOE's Yucca Mountain Repository.[76]

Congress has since provided no funding for Yucca Mountain-related activities. At the same time, however, Congress has not directed DOE to consider a repository at any other site in the United States, nor has it amended the NWPA. Thus permanent storage in the United States remains in policy limbo—the executive branch cannot move forward with developing a repository, but it is mandated by law to develop a repository at Yucca Mountain and to take custody of all civilian spent nuclear fuel, discussed below. The private sector cannot move forward because of federal law and the DOE Standard Contract without appropriations or additional direction from Congress. Little can be done to move forward on waste disposal options that don't violate the NWPA.

2. DOE Standard Contract and ensuring litigation

As the progress on developing a permanent repository stalled, other problems arose—namely, those related to the Standard Contracts DOE signed with utilities. The Standard Contract provided, as the NWPA requires, that DOE would take and receive title to spent fuel from civilian nuclear reactors, transport it, and dispose of it. In return—also per the NWPA—the Standard Contract set out the fees that the utility would pay into the Nuclear Waste Fund.[77] The owners or generators of civilian nuclear reactors were financially responsible for storing spent fuel on-site until the DOE could take custody of it.[78]

To state the obvious, fulfilling the Standard Contract depends on the existence of a high-level waste repository to take such waste to. As soon as it became apparent that DOE would not be able to take custody to utilities' spent fuel on-time, utilities began filing lawsuits against DOE for breach of contract. The Court of Appeals for the Federal Circuit has held—seventy-seven times over at this point—that DOE's failure to accept the spent fuel under the terms of the Standard Contract constitutes a breach of contract for which the utilities are entitled to damages.[79] DOE has settled an additional 44 cases to the same end.[80] The Department of Justice pays such damages out of the Department of the Treasury's Judgment Fund, which is financed by U.S. taxpayers and has no effect on the DOE budget. As of 2024, the U.S. government had paid $11.1 billion out of the Judgment Fund and estimated a remaining federal liability between $37.6 billion and $44.5 billion for litigation related to storing spent nuclear fuel.[81]

Meanwhile, utilities kept paying the fees into the Nuclear Waste Fund as mandated by the NWPA. In 2011, after the DOE filed to withdraw its application, the National Association of Regulatory Commissioners sued DOE over these fees, arguing that so long as the government has no viable alternative to Yucca Mountain as a depository for nuclear waste, the utilities should not be charged an annual fee to cover the cost of the disposal. At that point, utilities had been paying about $750 million per year—with such fees paid on top of the ongoing costs of storing spent nuclear fuel at reactor sites—and the balance of the Nuclear Waste Fund at the time had ballooned to $28.2 billion.[82] The D.C. Circuit agreed with the utilities in 2013, and the utilities' fees were frozen.[83] The fee was set to zero on May 16, 2014, and no new fees have been paid into the Nuclear Waste Fund since then.[84]

3. Still more problems with the Nuclear Waste Fund—it isn't an actual separate fund

A final issue stemming from the Standard Contracts was the Nuclear Waste Fund itself. According to several reports reviewed and summarized by the Government Accountability Office, the Nuclear Waste Fund was meant to be isolated from other federal programs in order to ensure predictable, adequate funding—and to keep the funds from being in competition with other funding priorities. However, a sequence of budget

---

[75] CRS, *supra* note 63 at 12-13.

[76] Clarion Energy Content Directors, *Yucca Mountain Nuclear Waste Storage License Could Cost $330mn*, POWER ENGINEERING, Mar. 10, 2025, available at https://www.power-eng.com/nuclear/yucca-mountain-nuclear-waste-storage-license-could-cost-330mn/.

[77] DOE, *Contract for Disposal of Spent Nuclear Fuel and/or High-level Radioactive Waste*, Art. II., available at https://www.nrc.gov/docs/ML0818/ML081850122.pdf.

[78] *See* 10 CFR Part 961 (Apr. 18, 1983).

[79] DOE, *supra* note 50 at 26-27.

[80] *Id*. at 26.

[81] *Id*. at 27.

[82] National Association of Regulatory Utility Commissioners (NARUC) brief at 5, in Nat'l Ass'n of Regul. Util. Comm'rs v. U.S. Dep't of Energy, 736 F.3d 517 (D.C. Cir. 2013).

[83] Nat'l Ass'n of Regul. Util. Comm'rs v. U.S. Dep't of Energy, 736 F.3d 517 (D.C. Cir. 2013).

[84] GAO, COMMERCIAL SPENT NUCLEAR FUEL 18 (2021).

reconciliation measures in the 1980s thwarted these aims. A law in 1985 split the fund between "mandatory" and "discretionary" sides of the budget—subjecting the utilities' fees and any expenditures to different budgetary rules—and in 1987, the Office of Management and Budget eliminated the Nuclear Waste Fund's separate budget planning target, leaving it instead to compete against other DOE programs marked as "discretionary" spending.[85]

The end result of this change was that utility payments made into the Nuclear Waste Fund—mandated by the NWPA to be used for the nation's long-term storage of high-level waste—went into the general treasury. This means there is no separate "fund" of the fees collected from utilities to pay for a waste repository or any other waste disposal option.

Because the Nuclear Waste Fund is not a separate fund, any legislation authorizing expenditures from the Nuclear Waste Fund would have to be "scored" against statutory budget caps, making it more challenging to act on such funds. Government "scoring" refers to the process of analyzing and estimating the financial impact of proposed legislation or programs, typically conducted by entities like the Congressional Budget Office in the United States.[86] While scoring ensures fiscal responsibility and transparency, it can often slow down progress. Proposed initiatives that score poorly—indicating high costs or increased deficits—face significant political and public resistance, even if their long-term benefits outweigh upfront expenses. Additionally, the complexity and uncertainty of scoring methods can result in overestimations or underestimations, discouraging policymakers from pursuing innovative but initially costly ideas.

In the case of the Nuclear Waste Fund, it "scores" high because it significant requires government spending, even though the source of such spending has already come from—that is, been paid for by—the U.S. nuclear industry from their payments into the Nuclear Waste Fund. This budgetary catch-22 discourages members of Congress from advocating for using the Nuclear Waste Fund, even for its original purpose.

4. Complications with NRC licensing due to lack of permanent waste repository

Stalled progress on spent fuel storage also led to a licensing complication at the NRC. Since 1979, the NRC has been required to determine that spent fuel from nuclear reactors can be safely disposed of before the NRC may issue a license for that reactor. The NRC therefore issued a Waste Confidence Decision in 1984 stating that spent fuel could be safely stored on-site for at least thirty years after a plant closes, and that a permanent geologic repository would be available between 2007 and 2009.[87] As the timeline for the repository slipped, the NRC amended its decision. The NRC issued another Waste Confidence Decision in 2010, after the Obama administration suspended work on Yucca Mountain Repository, in which the NRC stated that spent fuel could be safely stored on-site for at least sixty years after shutdown and that a repository would be available "when necessary."[88]

A coalition led by the State of New York sued the NRC over this 2010 decision, arguing the NRC had not adequately considered the effects of long-term storage at a reactor site. The D.C. Circuit agreed and ordered the NRC to revisit its finding.[89] The NRC subsequently issued a final rule in 2014 that replaced the Waste Confidence Decision and promulgated a General Environmental Impact Statement analyzing the potential effects of long-term storage of spent fuel at reactor sites. The NRC concluded that even should a repository never become available, the environmental impact of storing spent fuel on-site was minimal.[90] While the final rule and Generic Environmental Impact Statement reduce the need for site-specific considerations of spent fuel storage for each license application—including subsequent license renewals of existing reactors—they still place the burden on individual licensees to adequately store their spent nuclear fuel as part of reactor operations.

d. U.S. government attempt to reset and figure out a path forward: The Blue Ribbon Commission Report

In 2012, at the request of President Obama, the Secretary of Energy formed the Blue Ribbon Commission on America's Nuclear Future—or the Blue Ribbon Commission for short—to conduct a comprehensive

[85] GAO, COMMERCIAL SPENT NUCLEAR FUEL 17-18 (2021).
[86] OMB, U.S. Government Legislation Scoring, Section 21, available at https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/a11_current_year/s21.pdf.
[87] NRC, Waste Confidence Decision, 49 Fed. Reg. 34,658 (Aug. 31, 1984).
[88] NRC, Waste Confidence Decision Update, 75 Fed. Reg. 81,037 (Dec. 23, 2010).
[89] *See generally* CRS, *supra* note 63 at 14.
[90] NRC, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel (NUREG-2157)*, updated Mar. 9, 2021, available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2157/index.html.

review of policies for managing the back end of the nuclear fuel cycle and recommend a new strategy. The Blue Ribbon Commission concluded that a continued failure to deal with the nation's spent nuclear fuel would be costly to utilities and taxpayers, damaging to state-federal relations and public competence in the federal government, and burdensome to future generations who would have to solve the so-called waste issue.

The Blue Ribbon Commission therefore issued a number of recommendations for the U.S. government:

- **Consent-based siting.** Adopt a new, consent-based approach to siting future spent fuel and high-level waste management facilities. Acknowledging how difficult it has been to find sites where all levels of government, any affected tribes, and the host community are willing to accept a repository, the Blue Ribbon Commission concluded that any attempt to force a top-down solution would take longer, cost more, and have lower odds of ultimate success.[91] As such, the Blue Ribbon Commission recommended an approach whereby host communities could volunteer for a repository, or a spent fuel management organization could approach them. After extended negotiations between the organization and state, tribal, and local governments, the entities involved could form a legally enforceable agreement that includes commitments to all involved. This willingness to enter into a legal agreement would be a "good gauge" of consent. The Blue Ribbon Commission emphasized that all affected levels of government must have a meaningful consultative role in important decisions, and that transparency, flexibility, patience, responsiveness, and cooperation would all be necessary to achieving a successful result.[92] Setting a timeframe bounded by years, instead of specific dates as the NWPA did, would also help this process.[93]

- **Dedicated spent fuel and high-level waste management organization.** The Blue Ribbon Commission recommended that a new, single-purpose organization should implement the waste management program given the overall record of DOE and the federal government thus far. The new organization would be responsible for siting, licensing, building, and operating repositories, as well as for arranging transport of spent nuclear fuel and high-level waste and for undertaking research, development, and demonstration related to their management. The Blue Ribbon Commission recommended a congressionally chartered federal corporation, but whatever the form, it concluded the organization must have "a substantial degree of implementing authority and assured access to funds" paired with rigorous and independent financial, technical, and regulatory oversight.[94]

- **Nuclear Waste Fund.** Given the issues with the Nuclear Waste Fund, the Blue Ribbon Commission also recommended solutions to these issues so that the Nuclear Waste Fund could be used for its intended purpose—paying for the long-term storage of spent nuclear fuel and high-level waste. The Blue Ribbon Commission urged the administration to amend the Standard Contract so that utilities remit only the annual fee appropriated for waste management and place the rest into a third-party trust account. Further, it recommended that the budgetary treatment of utility fees and fund expenditures begun in 1987 must be corrected. Finally, legislation should mandate transfer of the unspent balance in the Nuclear Waste Fund to the new waste management organization so it could carry out waste management responsibilities independent of annual appropriations.[95] While these recommendations were published before utility fees into the Nuclear Waste Fund were frozen, they remain important suggestions for any future payment into or use of the fund.

Therefore, when it comes to the U.S. spent fuel policy, little, if anything, has worked according to what was envisioned in the NWPA. That doesn't mean that there are not possible paths forward – as the next section detailing what other countries are doing shows. Congress will need to act to enable the U.S. to move forward on this issue.

V. What other countries do with their spent fuel and high-level waste

The United States has evidently struggled to address the complexities of high-level nuclear waste and spent fuel management, while other countries have successfully implemented programs to tackle these challenges effectively.

Many countries around the world have developed advanced systems for managing spent fuel, incorporating a range of strategies for storage, including deep geological repositories for permanent storage, on-site dry cask storage

[91] BRC Report, *supra* note 13 at viii-ix.
[92] *Id*. at ix.
[93] *Id*. at x.
[94] *Id*.
[95] *Id*. at xi.

and spent fuel pools for interim containment, reprocessing and recycling to recover usable materials from spent fuel, and experimental technologies like vitrification (encasing waste in glass) and transmutation (altering isotopes to reduce radioactivity), all designed to ensure environmental safety and sustainability. Of all the options, decades of research has demonstrated that deep geological disposal, or a repository, is one of the most effective methods for removing highly radioactive waste from human contact for hundreds of thousands of years as it decays.

Separately or in parallel, recycling and reprocessing can reduce the volume of spent fuel needed to be disposed of and enhance resource efficiency. While the terms are often used interchangeably, "reprocessing" specifically refers to separating plutonium and uranium from spent fuel, which "recycling" means using reprocessed material to create new fuels for commercial power reactors. Reprocessing of fuel has long been employed by countries like the United Kingdom, Russia, and Japan, and it works best especially from a non-proliferation standpoint when paired with immediate recycling. [96]

While each nation's approach specific varies based on geographic, political, and technological factors, common practices include centralized storage facilities for spent nuclear fuel, ongoing research into waste recycling and reprocessing technologies, and the establishment of deep geological repositories for permanent disposal.[97] Countries like France have made significant strides in recycling nuclear waste, recovering usable materials from spent fuel, and reducing the long-term radiological impact.[98] Meanwhile, nations such as Finland and Canada have progressed in developing deep geological repositories, where waste is stored in stable geological formations underground.[99]

These international approaches reflect diverse national policies and technological advancements, offering valuable insights for improving spent fuel and high-level waste management practices in the United States and globally. Below are a some specific examples of the approaches other countries take.

- **France.** France implements a number of different programs. It is a leader in nuclear fuel recycling, and it routinely reprocesses and recycles a significant amount of used fuel. Around 17% of France's nuclear electricity is produced with recycled fuel. French utility EDF has capabilities to store reprocessed uranium for up to 250 years as a strategic reserve. Currently, reprocessing of 1100 tonnes of EDF used fuel per year produces 11 tonnes of plutonium (immediately recycled as mixed oxide fuel, or MOX fuel) and 1045 tonnes of reprocessed uranium converted into stable oxide form for storage.[100] The EDF also proposed a 15-hectare recycling plant near the closed Fessenheim nuclear site to process 500,000 tonnes of low-level radioactive metal over 40 years. Additionally, France is constructing a geological repository for the disposal of HLW and the reprocessing of spent fuel.[101] France gets about 65–

[96] WNA, *Processing of Used Nuclear Fuel*, updated Aug. 23, 2024, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel#:~:text=A%20key%2C%20nearly%20unique%2C%20characteristic,resource%20rather%20than%20a%20waste.

[97] WNA, *Storage and Disposal of Radioactive Waste*, updated Apr. 30, 2024, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste.

[98] *Id.*; IAEA, *France's Efficiency in the Nuclear Fuel Cycle: What Can 'Oui' Learn?*, Sept. 4, 2019, available at https://www.iaea.org/newscenter/news/frances-efficiency-in-the-nuclear-fuel-cycle-what-can-oui-learn; Électricité de France (EDF), *Management of Radioactive Waste*, available at https://www.edf.fr/en/the-edf-group/producing-a-climate-friendly-energy/nuclear-energy/edf-unique-expertise-in-nuclear-power-creation/management-of-radioactive-waste#:~:text=Cyclife%2C%20a%20subsidiary%20of%20EDF,on%20regulations%2C%20to%20recycle%20it (last visited Dec. 11, 2024).

[99] Canada Nuclear Waste Management Organization, *Canada's Deep Geological Depository*, available at https://www.nwmo.ca/canadas-plan/canadas-deep-geological-repository# (last visited Dec. 11, 2024); Nuclear Newswire, *Finland Begins Trial Run of Onkalo Repository*, Sept. 3, 2024, available at https://www.ans.org/news/article-6349/finland-begins-trial-run-of-onkalo-repository/; Vattenfall, *Finland to Open the World's First Final Repository for Spent Nuclear Fuel*, Aug. 23, 2023, available at https://group.vattenfall.com/press-and-media/newsroom/2023/finland-to-open-the-worlds-first-final-repository-for-spent-nuclear-fuel.

[100] WNA, *supra* note 85.

[101] *See Overview of Frances' Cigeo*, available at https://international.andra.fr/solutions-long-lived-waste/cigeo.

70% of its electricity from nuclear power, which is the highest share in the world.[102]

- **Finland.** While there is no reprocessing facility in Finland, after removal from the reactor, spent fuel is stored in interim pool-type storages at the power plant sites.[103] The storage period lasts 30-50 years, after which the spent fuel will be disposed of deep in the Finnish bedrock. Posiva, a Finnish company, built and operates Finland's spent fuel repository, based on a method developed by Swedish Nuclear Fuel Management Company SKB.[104] Finland will thus be one of the first countries to provide a repository in which spent fuel and high-level waste can be safely stored for at least 100,000 years.

- **Japan.** Japan primarily manages its spent fuel in a variety of ways over the years, including reprocessing it to recover reusable uranium and plutonium and storing the remaining high-level radioactive waste in a vitrified form at dedicated facilities.[105] This was primarily led by the Japan Atomic Energy Agency at its Tokai facility before the facility ceased operations.[106] Tokai previously reprocessed spent nuclear fuel, producing mixed uranium-plutonium products and vitrified HLW canisters. Although the facility ceased large-scale operations in 2014, it continues to focus on HLW vitrification and decommissioning.[107] Japan is one of the few countries that utilizes vitrification for its high-level waste, encasing the radioactive material in stable glass blocks to immobilize it and ensure safe, long-term storage and disposal.[108] Japan is also finalizing the construction of the Rokkasho Nuclear Fuel Reprocessing Facility, which is a nuclear reprocessing plant owned by Japan Nuclear Fuel Limited ("JNFL") with an annual capacity of 800 tons of uranium or 8 tons of plutonium.[109] Construction of Rokkasho has been delayed and JNFL expects completion to occur in 2026.

- **Russia.** Russia has a number of ways to handle spent fuel and high-level waste, including burial. Low- and medium-level radioactive waste is buried in designated areas, such as the Severny Landfill in Zheleznogorsk, and deep burial sites in Seversk and Dmitrovgrad.[110]

- **South Korea.** South Korea currently stores most of its spent fuel on-site at individual power plants, primarily in temporary storage facilities, while actively seeking a permanent disposal site for high-level waste.[111] Due to international agreements, South Korea does not currently reprocess spent nuclear fuel.[112] However, the South Korean government is actively looking for a suitable site to build a deep geological repository for high-level radioactive waste, aiming to have it operational by the mid-

---

[102] EIA, Today In Energy: France (January 2023), available at https://www.eia.gov/todayinenergy/detail.php?id=55259#:~:text=France%20has%20one%20of%20the,generation%20share%20in%20the%20world.

[103] IAEA, *Country Profile: Finland*, available at https://sris.iaea.org/country-overview/introduction/FI/Finland#:~:text=There%20is%20no%20reprocessing%20facility,deep%20in%20the%20Finnish%20bedrock (last visited Dec. 11, 2024).

[104] Vattenfall, *supra* note 88.

[105] Federation of Electric Power Companies of Japan (FEPC), *Nuclear Waste Management*, available at https://www.fepc.or.jp/english/nuclear/waste_management/index.html (last visited Dec. 11, 2024); FEPC, *Japan's Nuclear Fuel Cycle,* available at https://www.fepc.or.jp/english/nuclear/fuel_cycle/fuel_recycling/index.html (last visited Dec. 11, 2024).

[106] WNA, *Japan's Nuclear Fuel Cycle* (Jan. 2021), available at https://world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-fuel-cycle.

[107] Nuclear Engineering International, *Vitrification resumes at Japanese reprocessing plant* (2019), available at https://www.neimagazine.com/news/vitrification-resumes-at-japanese-reprocessing-plant-7322719/.

[108] FEPC, *The Challenge of High-level Radioactive Waste Disposal*, May 1999, available at https://www.fepc.or.jp/english/library/power_line/detail/04/#:~:text=The%20process%2C%20known%20as%20vitrification,JNFL)%20Vitrified%20Waste%20Storage%20Center.

[109] WNA, *Japan's Nuclear Fuel Cycle* (Jan. 2021), available at https://world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-fuel-cycle.

[110] IAEA, *Under One Roof: Russia's Integrated Strategy for Spent Fuel Management*, Aug. 2, 2019, available at https://www.iaea.org/newscenter/news/under-one-roof-russias-integrated-strategy-for-spent-fuel-management.

[111] WNA, *Nuclear Power in South Korea*, updated May 3, 2024, available at https://world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea#:~:text=Following%20PECOS'%20recommendations%20in%20June,largely%20due%20to%20transport%20costs.

[112] *Id*.

2050s.[113]

- **China.** China manages spent fuel primarily by storing low- and intermediate-level radioactive waste in near-surface disposal facilities, while planning to dispose of high-level radioactive waste in a centralized deep geological repository. The Chinese also vitrify their waste, mixing liquid waste with glass to solidify it for long-term storage; this approach involves extensive research and development of underground research laboratories to ensure safe disposal methods. The China National Nuclear Corporation is responsible for the development of a deep geological repository for used CANDU fuel, and for high-level waste from the reprocessing of used light water reactor fuel.[114] Site selection concluded in the 2020s, but a repository is not yet constructed.[115]

- **United Kingdom.** The United Kingdom plans to manage its spent fuel and hazardous waste by deep geological disposal. The UK government launched a site selection process in 2020 to find a community that would host a Geological Disposal Facility (GDF).[116] The facility will be designed to contain the waste permanently, and the waste will not be retrieved after the facility is closed. While a GDF is not expected to be ready until the 2050s, a shallower disposal facility – which is up to 200m below ground - could be available in 10 years in England and Wales allowing for quicker decommissioning.[117]

- **Sweden.** Sweden's spent fuel management strategy involves storing spent nuclear fuel in a final repository and in a mid-term storage capsule. The Swedish Nuclear Fuel and Waste Management Company (SKB) is building a final repository for spent nuclear fuel in Forsmark, about 80 miles north of Stockholm.[118] The repository will be located 500 meters underground in mined bedrock and will use a disposal method called KBS-3. KBS-3 involves encapsulating spent fuel in copper canisters, which are then surrounded by bentonite clay. The repository will be able to hold 12,000 tons of spent fuel and is designed to keep the waste safe for 100,000 years. Construction is expected to begin in 2025.

It is important to note that nuclear waste management is a complex issue with various technical, political, and societal challenges. Different countries have adopted diverse approaches based on their specific circumstances and national policies.

VI. Consolidated Interim Storage as part of an integrated spent fuel management strategy

For the ultimate disposal of spent fuel and high-level waste in the United States, geologic repositories are considered the most viable option (and the one required by law).[119] But consolidated interim storage, or CIS facilities, which are away-from-reactor concrete pads upon which spent fuel casks are stored, are an important intermediate step between at-reactor ISFSIs and permanent repositories.

The goal of a CIS facility is to store the spent fuel in a safe, secure, and centralized location, rather than at individual nuclear power plant sites all over the country, until a permanent solution is available. While intended to be interim in nature, CIS facilities are designed with long-term safety in mind, providing a stable solution until construction and operation of a permanent repository or disposal site. CIS facilities also offer logistical and economic benefits, including improved waste management efficiency and the ability to support eventual transportation to a final disposal facility.

There are currently two proposed CIS facilities that have been licensed by the NRC, one in Texas and one in New Mexico, although both are subject to current court

[113] World Nuclear News, *South Korea Seeks Site for Underground Research Facility*, June 18, 2024, available at https://www.world-nuclear-news.org/Articles/South-Korea-seeks-site-for-underground-research-fa#:~:text=MOTIE%20and%20KORAD%20noted%20that,Most%20Read.

[114] NWMO, *What Other Countries Are Doing*, available at https://www.nwmo.ca/canadas-plan/what-other-countries-are-doing (last visited Dec. 11, 2024).

[115] *Id*.

[116] United Kingdom Environment Agency, *Regulating Radioactive Waste—What We Do and Why*, Nov. 30, 2020, available at https://environmentagency.blog.gov.uk/2020/11/30/regulating-radioactive-waste-what-we-do-and-why/; New Scientist, *The UK's Nuclear Waste and the Geological Solution*, Mar. 23, 2022, available at https://www.newscientist.com/article/2313277-the-uks-nuclear-waste-and-the-geological-solution/.

[117] Gov.UK, Updated Approach to Managing Nuclear Waste (May 2024), available at https://www.gov.uk/government/news/updated-approach-to-managing-nuclear-waste.

[118] SKB, *Managing the Swedish Nuclear Waste*, available at https://skb.com/ (last visited Dec. 11, 2024).

[119] *Id*.

challenge as explained below.[120] In 2006, the NRC licensed another CIS, the Private Fuel Storage facility, in Utah, but the facility was never built.[121] At the time of the Private Fuel Storage facility licensing, the NRC's authority to license a CIS facility was challenged in federal courts and in two circuit court decisions (one case by the D.C. Circuit and the other by the Tenth Circuit), in both of which the court upheld the NRC's authority to license the CIS under the Atomic Energy Act ("AEA").[122]

The DOE is currently working on establishing a federal CIS facility to address the nation's growing spent nuclear fuel inventory.[123] This facility would be selected through a consent-based siting process, involving community input and engagement. This facility would also be the first federal CIS facility option. Notably, this plan would have faced potential compliance challenges under the NWPA; namely, the NWPA generally restricts DOE from establishing centralized interim storage facilities unless progress is demonstrable toward licensing a permanent repository. This provision aims to ensure that interim solutions do not become de facto permanent. However, to navigate the NWPA's limitations and establish a federal CIS facility, Congress has directed and funded DOE to move forward with identifying a site for a federal consolidated interim storage facility using a consent-based approach.[124] DOE may also collaborate with private entities pursuing CIS facilities under NRC licenses—which could circumvent the any potential NWPA restrictions and leverage private sector capabilities.

a. Two proposed CIS facilities and recent court challenges

The NRC has recently licensed two proposed CIS facilities: a facility by Interim Storage Partners, LLC ("ISP") in Texas and one by Holtec International in New Mexico.[125] In 2016 and 2017, the NRC received the applications for Holtec International and ISP, respectively, to construct their respective CIS facilities under 10 CFR Part 72 of the NRC's regulations. The NRC granted licenses for the CIS facility in Andrews County, Texas and the CIS facility in Lea County, New Mexico in 2021.

Both the licenses were challenged in court, with court determining the NRC did not have the authority under the AEA to license the CIS facilities. In the cases *Texas v. Nuclear Regulatory Commission* and *Fasken Land and Minerals et al. v. Nuclear Regulatory Commission*,[126] the licenses for both existing CIS facilities were challenged in Texas, in the Fifth Circuit, with the court ultimately ruling that the NRC did not have the authority to license a CIS under the AEA or the NWPA, and further referencing the U.S. Supreme Court's newly adopted "major questions doctrine." The NRC's authority had previously been recognized to extend to CIS licensing by the D.C. Circuit in *Bullcreek v. Nuclear Regulatory Commission* and the Tenth Circuit in *Skull Valley Band of Goshute Indians v. Nielson*,[127] when the NRC licensed an away-from-reactor CIS facility in the early 2000s. This decision from the Fifth Circuit created a circuit split between the various courts on the NRC's authority to license private CIS facilities. To further deepen the split, the D.C. Circuit affirmed the NRC's authority to license facilities for the away-from-reactor interim storage of spent nuclear fuel.[128]

---

[120] NRC, *Consolidated Interim Storage Facility (CISF)*, updated Dec. 8, 2020, available at https://www.nrc.gov/waste/spent-fuel-storage/cis.html.

[121] NRC, *NRC Issues License to Interim Storage Partners for Consolidated Spent Nuclear Fuel Interim Storage Facility in Texas*, Sept. 13, 2021, available at https://www.nrc.gov/reading-rm/doc-collections/news/2021/21-036.pdf.

[122] Note, for NRC licensing decisions, as a general matter, the federal circuit courts have direct appellate review, and the appeal can be brought in either the D.C. Circuit or the circuit court where the proposed facility is located.

[123] DOE, *Department of Energy Moves Forward with Consolidated Interim Storage Facility Project for Spent Nuclear Fuel*, May 15, 2024, available at https://www.energy.gov/ne/articles/department-energy-moves-forward-consolidated-interim-storage-facility-project-spent.

[124] DOE/Pacific Northwest National Laboratory (PNNL), *Consent-Based Siting for Consolidated Interim Storage*, Oct. 2, 2024, available at https://eedgis.pnnl.gov/portal/apps/storymaps/stories/34462804fe664a5980e93fc4b6026f42.

[125] NRC, *Holtec International—HI-Store CISF*, updated May 9, 2023, available at https://www.nrc.gov/waste/spent-fuel-storage/cis/holtec-international.html; Orano USA, the U.S. subsidiary of the French global nuclear fuel cycle company, and Waste Control Specialists (WCS) formed a joint venture, ISP, to construct and operate a CIS facility for spent nuclear fuel at an existing WCS site in Andrews County, Texas.

[126] *Texas v. Nuclear Regulatory Commission*, 78 F.4th 827 (5th Cir. 2023); *Fasken Land & Minerals, Ltd. v. Nuclear Regulatory Commission*, No. 23-60377, 2024 WL 3175460 (5th Cir. Mar. 27, 2024).

[127] *Bullcreek v. Nuclear Regulatory Commission*, 359 F.3d 536 (D.C. Cir. 2004); *Skull Valley Band of Goshute Indians v.* Nielson, 376 F.3d 1223 (10th Cir. 2004).

128 *See B*eyond Nuclear v. Nuclear Regulatory Commission, No. 20-1187 (D.C. Cir. 2024).

In October 2024, the Supreme Court announced that it would take up the case related to the NRC's ability to license away-from-reactor interim storage of spent nuclear fuel to private licensees.[129] By hearing the case, the Supreme Court will determine the extent of the NRC's statutory authority to issue such licenses—and may rule on other administrative law doctrines as well. The Supreme Court need not rule on all the issues the Fifth Circuit decided *Texas v. NRC* on. However, it now has the ability to issue potentially far-reaching rulings on the NRC's statutory licensing authority, the major questions doctrine, and the Hobbs Act, which governs challenges to NRC licensing decisions.

VII. Reprocessing and Recycling

One method to reduce the quantity of nuclear waste that must be stored is to reprocess and recycle the fuel. As noted earlier, when spent nuclear fuel comes out of the reactor, it still contains about 95% usable material, mostly uranium with a very small amount of plutonium. Reprocessing separates the remaining fissile uranium and plutonium, while recycling turns the removed fissile material into usable nuclear fuel. While technically feasible and successfully implemented in other countries, these processes have policy baggage in the United States that stunts development of a successful reprocessing or recycling program, largely due to a combination of nonproliferation and cost concerns.

a. Technical overview of reprocessing and recycling

Reprocessing separates the residual uranium and plutonium—that reusable 95%—from the other isotopes created during the fission reaction so that it can be turned into nuclear fuel again.[130]

Extracting usable material from spent nuclear fuel is a complicated technical process that can involve a variety of chemical methods. The most common method used today is a method called PUREX, originally developed at U.S. national laboratories in the 1950s, whereby used fuel is leeched using a chemical solution of nitric acid. The chemical slurry is then processed through several cycles of solvent extraction to separate the uranium and plutonium products.[131] The result of reprocessing must contain a precise ratio of uranium and plutonium in order to be recycled for use in a nuclear reactor. Once separated, the fissile material can be turned into mixed oxide or "MOX" fuel, which can be substituted for fresh uranium oxide fuel in nuclear reactors.

Recycled MOX fuel has been produced in Europe for decades and is used in reactors in Belgium, Switzerland, Germany, France, and the UK.[132] Despite its difficulty, as discussed above, other countries' mastery of fuel recycling—and the clear benefits derived from it—show that the United States' lack of capability is far more the result of policy than physics.

b. History of reprocessing and recycling in the United States

Early reprocessing technology stemmed from the Manhattan Project, during which the U.S. government separated plutonium for weapons production. The first suggestion that reprocessing could be part of the U.S. spent nuclear fuel management policy arose in the mid-1950s. Early efforts involved research and demonstration, including the Experimental Breeder Reactor at Argonne National Laboratory West—today known as Idaho National Laboratory—and an official grant of authority to the AEC to license reprocessing facilities. An initial commercial reprocessing facility opened at West Valley, New York, and operated from 1966 to 1972, but it closed due to cost and regulatory issues and was transferred to DOE for management in 1980.[133]

In 1976, President Ford deferred commercial reprocessing and recycling due to proliferation concerns—that reprocessing involves separating a small amount of plutonium from the spent nuclear fuel, and "the same plutonium produced in nuclear power plants can, when

---

[129] The cases, *U.S. Nuclear Regulatory Commission et al. v. State of Texas et al.* and *Interim Storage Partners LLC v. Texas et al.*, (collectively, *NRC v. Texas*), are both appeals from an August 2023 Fifth Circuit decision.

[130] NRC, *Backgrounder on Radioactive Waste*, updated Jan. 26, 2024, available at https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html.

[131] M. F. Simpson & J. D. Law, *Nuclear Fuel Reprocessing*, IDAHO NATIONAL LAB. (Feb. 2010) at 7-8, available at https://inldigitallibrary.inl.gov/sites/sti/sti/4460757.pdf; *see also* WNA, *Processing of Used Nuclear Fuel*, updated Aug. 23, 2024, available at https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel.

[132] *Backgrounder on Mixed Oxide Fuel*, U.S. NUCLEAR REGULATORY COMMISSION https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/mox-bg.html

[133] CRS, *Nuclear Fuel Reprocessing: U.S. Policy Development*, Mar. 27, 2008, available at https://sgp.fas.org/crs/nuke/RS22542.pdf; DOE, *West Valley Demonstration Project: Site History*, available at https://www.energy.gov/wvdp/site-history (last visited Dec. 11, 2024).

chemically separated, also be used to make nuclear explosives."[134] President Carter made this deferral permanent by extending it indefinitely in 1977, directing the federal government instead to focus on alternative fuel cycles and re-assess future spent fuel storage needs.[135] While President Reagan lifted this ban in 1981, the U.S. policy on reprocessing has been unstable ever since; Presidents Reagan, Clinton, and Bush all issued alternating policy directives on reprocessing.[136]

Partially as a result of the near-constant changes in reprocessing policy, no real domestic reprocessing capability has emerged in the United States. The idea that any administration can so easily reverse policy on reprocessing has created uncertainty for private industry and has effectively prevented a commercial reprocessing industry from developing. At the federal level, every administration since President Ford has at least considered reprocessing, but all abandoned it due to a combination of cost and nonproliferation concerns.[137] Efforts since the 1970s to develop a domestic reprocessing capability have therefore been stilted.

The NRC has evaluated how to license a commercial reprocessing facility, to no formal result. Upon direction from Congress, and with the establishment of a policy initiative called the Global Nuclear Energy Partnership—which would focus on developing proliferation-resistant reprocessing technologies—the NRC began considering how to license a reprocessing facility in 2006.[138] After years of public meetings, in 2013, the NRC staff published a potential regulatory framework for reprocessing, where they outlined the ways a reprocessing facility could be licensed and regulated under both the existing regulations and with new rulemaking.[139] The Commission recommended the staff develop a new rule for licensing reprocessing facilities, to be promulgated in a new part of NRC regulations pertaining to special nuclear material, informally referred to as 10 CFR Part 7X.[140] However, the NRC suspended work on the rulemaking in 2016 due to budgetary constraints and an absence of reprocessing projects on the horizon. While the Nuclear Energy Institute and industry representatives supported the continuation of a reprocessing rulemaking, they acknowledged that there were no plans to submit an application for a reprocessing facility for the foreseeable future.[141] The NRC officially discontinued the rulemaking in 2021.[142]

c. Reprocessing and recycling currently in the United States

While federal policy has stalled on reprocessing and recycling, the private sector has started to take matters into its own hands. Some advanced reactor designs involve reprocessing spent fuel to separate uranium, plutonium, and other long-lived radioisotopes, then recycling those components—sometimes multiple times—to make new

---

[134] *Statement of President Gerald R. Ford on Nuclear Policy*, NUCLEAR POLICY (Oct. 28, 1976), available at https://www.nrc.gov/docs/ml1209/ML120960611.pdf.
[135] BRC Report, *supra* note 13 at 20.
[136] National Archives, *President Ronald Reagan: Statement Announcing a Series of Policy Initiatives on Nuclear Energy*, Oct. 8, 1981, available at https://www.reaganlibrary.gov/archives/speech/statement-announcing-series-policy-initiatives-nuclear-energy; The White House, Office of the Press Secretary, *President Clinton Fact Sheet on Nonproliferation And Export Control Policy*, September 27, 1993, available at https://www.rertr.anl.gov/REFDOCS/PRES93NP.html; 71 Fed. Reg. at 44,673-44,676 (Aug. 7, 2006) (Bush).
[137] *Id.*
[138] NRC, *SECY-06-0066 Regulatory and Resource Implementations of a Department of Energy Spent Nuclear Fuel Recycling Program*, Mar. 22, 2006, available at https://www.nrc.gov/docs/ML0604/ML060410386.pdf; *see also* NRC, *SECY-07-0081 Regulatory Options For Licensing Facilities Associated With The Global Nuclear Energy Partnership*, June 27, 2007, available at https://www.nrc.gov/docs/ML0718/ML071800282.pdf; DOE, *The Global Nuclear Energy Partnership: Greater Energy Security in a Cleaner, Safer World*, Feb. 6, 2006, available at https://www.energy.gov/articles/global-nuclear-energy-partnership-greater-energy-security-cleaner-safer-world.
[139] NRC, *SECY-13-0093 Reprocessing Regulatory Framework - Status and Next Steps*, Aug. 20, 2013, available at https://www.nrc.gov/docs/ML1317/ML13178A243.pdf
[140] NRC, *Staff Requirements – SECY-13-0093 – Reprocessing Regulatory Framework – Status And Next Steps*, Nov. 4, 2013, available at https://www.nrc.gov/reading-rm/doc-collections/commission/srm/2013/2013-0093srm.pdf.
[141] NRC, *Reprocessing*, updated May 15, 2023, available at https://www.nrc.gov/materials/reprocessing.html.
[142] NRC, *SECY-21-0026 Discontinuation of Rulemaking - Spent Fuel Reprocessing*, Mar. 5, 2021 available at https://www.nrc.gov/docs/ML2030/ML20301A388.pdf; NRC, *SRM-SECY-21-0026 Discontinuation of Rulemaking - Spent Fuel Reprocessing*, June 24, 2021, available at https://www.nrc.gov/docs/ML2117/ML21175A065.pdf (approving the discontinuation of the rulemaking).

fuel for fast reactors.[143] Essentially, rather than designing a reactor and then thinking about how to manage the spent fuel—which is how traditional light-water reactors were developed—these reactor concepts think about spent fuel as a core aspect of the reactor design, and even an asset. Advanced reactor company Oklo is pursuing fuel recycling based on electrorefining technology that will process fuel for Oklo's metal-fueled fast reactors, as well as a fuel fabrication facility at Idaho National Laboratory that will turn material recovered from DOE's shutdown Experimental Breeder Reactor-II into HALEU-based fuel, which Oklo's reactors can also accept.[144] Startup Curio is developing an electrolysis-based technology that would reprocess spent nuclear fuel in the United States, with a goal of eventually creating products that can be recycled into new fuel for nuclear reactors.[145] Curio's process aims to avoid production of pure plutonium—lending it a non-proliferation edge—and dramatically reduce the waste volumes compared with existing processes.[146]

These private efforts are gaining support from the Advanced Research Projects Agency – Energy ("ARPA-E")—an energy-focused research and development agency of the U.S. government that has funded, among other things, new methods of recycling spent fuel and high-level waste. Among other things, ARPA-E's CURIE program awarded $38 million to universities, national laboratories, and private companies to develop technologies to advance spent nuclear fuel recycling and provide safe, domestic advanced reactor fuel.[147] The NEWTON program will fund research and development into transmutation of spent nuclear fuel, which could transform the non-uranium, non-plutonium isotopes in spent fuel that otherwise would need to be stored as waste, thereby reducing the volume of the national spent fuel stockpile.[148] These programs look beyond the traditional technologies and methods for reprocessing and recycling and aim to help the United States use spent nuclear fuel as an asset, not a waste product.

VIII. Spent fuel management—where are we now in the United States?

With all the ongoing activities in new nuclear today, it is a ripe time to explore—and pursue—matters pertaining to spent fuel to include reprocessing, recycling, CIS, and permanent disposal paths. Importantly, any path forward will require action by Congress, as the NWPA prevents DOE from being able to pursue any long-term solution other than a permanent repository at Yucca Mountain. Further, the Nuclear Waste Fund should be separated from the general treasury in order to make it feasible to appropriate money from it.

Despite these challenges, there have been occasional efforts to address some of the issues with spent nuclear fuel and high-level waste management in recent years. Some of the more recent developments in spent fuel and high-level waste management include the following:

- **Proposed Legislation.** In recent years, Congress has at least attempted to remedy the NWPA and related issues. In the 118th Congress, the bipartisan Nuclear Waste Administration Act of 2024 proposed to establish an independent agency to manage the country's nuclear waste—per the Blue Ribbon Commission report—and insulate the management of spent nuclear fuel from political changes. The bill would also direct a consent-based siting process for waste facilities, as well as ensure reliable funding for managing spent fuel by providing access to the Nuclear Waste Fund and create a separate Working

[143] Congressional Research Service (CRS), *Nuclear Energy: Overview of Congressional Issues* 4-5 (2024), available at https://sgp.fas.org/crs/misc/R42853.pdf.

[144] *Enabling the Near Term Commercialization of an Electrorefining Facility to Close the Metal Fuel Cycle*, ARPA-E ONWARDS, available at https://arpa-e.energy.gov/technologies/projects/enabling-near-term-commercialization-electrorefining-facility-close-metal; *U.S. Department of Energy Signs Off on Oklo Fuel Fabrication Facility Design Concept*, U.S. DEPT. OF ENERGY, Oct. 15, 2024, available at https://www.energy.gov/ne/articles/us-department-energy-signs-oklo-fuel-fabrication-facility-design-concept.

[145] *Curio Solutions Awarded GAIN Voucher to Advance New Spent Fuel Recycling Process*, U.S. DEPT. OF ENERGY, Mar. 21, 2023, available at https://www.energy.gov/ne/articles/curio-solutions-awarded-gain-voucher-advance-new-spent-fuel-recycling-process.

[146] *Closing the Cycle with NuCycle*, ARPA-E, available at https://arpa-e.energy.gov/technologies/projects/closing-cycle-nucycletm.

[147] *U.S. Department of Energy Awards $38 Million for Projects Leading Used Nuclear Fuel Recycling Initiative*, ARPA-E, Oct. 21, 2022, available at https://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-awards-38-million-projects-leading-used-nuclear.

[148] *Nuclear Energy Waste Transmutation Optimized Now*, ARPA-E, July 16, 2024, available at https://arpa-e.energy.gov/technologies/programs/newton.

Capital Fund.[149] These provisions also come from the Blue Ribbon Commission report. While this bill did not become law, its introduction shows congressional willingness to tackle the spent nuclear fuel management issue. Separately, the Nuclear REFUEL Act, introduced at the end of the 118th Congress in December 2024, would exclude reprocessing technology that does not separate plutonium from the definition of "production facility." This change seeks to clarify that such technology would be licensed under 10 CFR Part 70, which offers a streamlined licensing pathway compared to the more onerous 10 CFR Part 50—making it easier to license a reprocessing facility. It remains to be seen whether this proposal will turn into reality.[150]

- **DOE Activities on Consent Based Siting.** One positive development is that in recent years DOE has adopted a consent-based siting approach, as the Blue Ribbon Commission recommended. On December 1, 2021, DOE issued a request for information on using consent-based siting to identify sites for interim storage of spent nuclear fuel, namely on how to best implement a consent-based siting process and remove barriers for meaningful participation.[151] DOE received 225 responses to its request for information and synthesized its findings into a report, where it acknowledged that it needed to "address[] the current deficit of trust in DOE" and ensure that its consent-based siting process is truly fair, inclusive, and community-first.[152]

- **Reprocessing and Recycling.** Private sector activities in reprocessing and recycling continue to move forward. As discussed above, companies like Oklo and Curio—and others supported by ARPA-E funding—are developing innovative ways to reduce the volumes of spent nuclear fuel and high-level waste or proactively plan for future spent fuel management, all while making reprocessing and recycling raise less non-proliferation concerns.

IX. Conclusion

Effective nuclear waste management and recycling are critical components of ensuring the long-term sustainability and growth of the nuclear energy industry. As global energy demands rise and the need for low-carbon solutions becomes ever more urgent, addressing the challenges of waste disposal, recycling technologies, and regulatory frameworks will be key to maintaining public confidence and securing a safe, reliable energy future. By advancing best practices in waste management, improving policy and legislation, and exploring innovative recycling methods, the nuclear sector can continue to play a vital role in combating climate change.

---

[149] H.R. 9786, *Nuclear Waste Administration Act of 2024*, Sept. 24, 2024, available at https://www.congress.gov/bill/118th-congress/house-bill/9786/text.

[150] H.R. 10321, Nuclear REFUEL Act, December 6, 2024, available at https://www.congress.gov/bill/118th-congress/house-bill/10321.

[151] 86 Fed. Reg. 68,244 (Dec. 1, 2021).

[152] DOE, *Consent-Based Siting Request for Information Comment Summary and Analysis*, 4 (Sept. 2022) available at https://www.energy.gov/sites/default/files/2022-09/Consent-Based%20Siting%20RFI%20Summary%20Report%200915.pdf.

FROM TERRAPOWER TO THE TRONA PATCH – WYOMING FUTURE HOME OF THE COUNTRY'S FIRST COMMERCIAL ADVANCED REACTORS --

Sam C. Kidd
Holland & Hart LLP
Cheyenne, Wyoming

One of Wyoming Governor Mark Gordon's priorities is for Wyoming to embrace an "all-of-the-above" energy strategy.[1] Wyoming has historically been a major energy exporter, whether that energy has been derived from Powder River Basin oil and coal or natural gas from the Green River Basin. According to the U.S. Energy Information Administration, Wyoming produces 12 times more energy than it consumes, ranking as the third-largest net energy exporting state behind only Texas and Pennsylvania.[2] Anyone who has spent much time in Wyoming (a ski trip to Jackson Hole doesn't count) knows that Wyoming is also rich in its wind resources. Wyoming has more than doubled its wind energy generation capacity since 2019.[3] And since TerraPower announced in 2021 that it would build the Western Hemisphere's first advanced non-Light Water Reactor (LWR) just outside of Kemmerer, Wyoming, Wyoming has remained on the leading edge of advanced reactor deployment by also partnering with BWXT Advanced Technologies, LLC (BWXT) to explore deploying advanced microreactors to provide produced heat and electricity to industrial users.

Despite Wyoming's status as a leading energy exporter, the U.S. Energy Information Administration also ranks Wyoming as the second-most energy-intensive economy in the country.[4] Extraction related industries make up a large portion of that energy-intensive economy. In September 2023, the Wyoming Energy Authority (WEA) and BWXT each committed approximately $10 million to assess the viability of microreactors to meet the electricity and industrial heat demands of Wyoming's trona mining industry.[5] The two-year, two-phase contract also includes assessing Wyoming's supply chain compatibilities for reactor component manufacturing and reactor deployment support. Currently in phase two, BWXT is working to complete conceptual design for deployment of its BWXT Advanced Nuclear Reactor (BANR), develop its regulatory engagement plan, and demonstrate the Wyoming supply chain's ability to manufacture nuclear components. The success of this public-private partnership is evidenced by the December 12, 2024, announcement from Tata Chemicals Soda Ash Partners LLC ("Tata Chemicals"), a Wyoming trona mining company, that it has signed a letter of intent with BWXT.[6] The letter of intent states that Tata Chemicals and BWXT will begin setting timelines with milestones and work to establish commercial terms and conditions for Tata Chemicals to acquire up to eight BANR reactors with the first to be deployed to its trona mine in the early 2030s.[7]

So why is Wyoming on the leading edge of advanced reactor deployment? What does BANR offer industrial users and what is next for BWXT and the WEA in the deployment of BANR in Wyoming? And finally, what are some of the remaining legal and regulatory challenges? This article will address each of these questions, but first, what exactly is trona?

That Yellow Box in the Refrigerator

[1] https://governor.wyo.gov/priorities
[2] Wyoming State Profile and Energy Estimates, U.S. Energy Information Administration, (last updated June 20, 2024) https://www.eia.gov/state/?sid=WY#:~:text=Wind%20power%20gen eration%20in%20Wyoming,at%20the%20end%20of%202023.
[3] *Id*.
[4] *Id*.
[5] *BWXT Awarded Contract to Evaluate Microreactor Deployment for State of Wyoming*, BWX Technologies, Inc. News (September 18, 2023) https://www.bwxt.com/news/2023/09/12/BWXT - Awarded-Contract-to-Evaluate-Microreactor-Deployment-for-State-of-Wyoming *see also Funding Recommended for School of Energy Resources – University of Wyoming with Frontier Carbon Solutions and Also BWXT Advanced Technologies LLC*, Wyoming Energy Authority Press Release (August 8, 2023) https://wyoenergy.org/emf-review-committee-recommends-two-projects/.
[6] *Tata Chemicals North America announces Letter of Intent (LOI) with BWXT to explore the deployment of eight BWXT Advanced Nuclear Reactors (BANR) in Wyoming*, Tata Chemicals Soda Ash Partners LLC Press Release (December 12, 2024) available at: https://www.tatachemicals.com/upload/content_pdf/BWXT-Tata-LOI-12-December-2024.pdf.
[7] *Id*.

Trona, which is about 70% sodium carbonate, is refined to produce sodium compounds, particularly soda ash.[8] Baking soda is refined from soda ash and soda ash is the second ingredient by weight after silica in glass. It is also a common ingredient in soaps, detergents, inorganic chemicals and other products. Soda ash is even used to help extract a chemical needed to make lithium batteries.[9] According to the Wyoming Mining Association, Wyoming has the world's largest trona deposit in the world, with over 200 billion tons of pure trona deposits, and supplies about 90% of the nation's soda ash.[10] Over 16.5 million tons of trona was extracted from Wyoming mines in 2023, and Trona is Wyoming's largest international export.[11]

The trona beds in Wyoming's Green River Formation lie between 600 and 2,000 feet underground.[12] Wyoming's trona mines have been compared to underground cities. At the Genesis Alkali mine, one of four companies mining Trona in the Green River Formation, there are over 2,500 miles of underground roadways, a mechanic shop with parts and computers, warehouses, eating areas and bathrooms.[13] The mining is done through a room-and-pillar system where parallel tunnels, or drifts, are cut through the rock with connections made between the drifts at regular intervals. This creates pillars that support the overlying rock, and the trona is cut from the mining face and processed.[14]

Trona mining and purification is depicted in the diagram below from the Wyoming Mining Association. It shows that steam, currently provided by coal and natural gas burning generators, is required at the crystallizer and dryer stages. Heat is also used in the calciner to burn off unwanted gasses (see Figure 1 at end of this article – Trona refining process).[15]

Mining and processing of trona is a twenty-four-hour-a-day, 365-day a year operation, that requires reliable and resilient electricity and a constant source of industrial heat. It also takes place in a relatively remote location. A fleet of microreactors like BANR can operate for years without refueling, and provide both process heat and electricity and process heat at the same time, which explains why Tata Chemicals has been in a cooperative agreement with BWXT to assess the viability of deploying BANR microreactors to supplement Tata Chemicals' existing power generation resources. [16] Tata Chemicals was the use-case for BWXT's WEA grant. After just over a year of this public-private partnership, Tata Chemicals' recently signed letter of intent with BWXT constitutes a significant step forward for the commercialization of microreactor technology in Wyoming and around the world.

But why Wyoming?

Wyoming's history as an energy producing state and its history of uranium extraction have undoubtedly contributed to the momentum Wyoming has generated in the advanced reactor space. Political leadership at the State and Federal level have also been instrumental in setting the conditions necessary for the commercial nuclear development taking place. It was a 2019 letter from Senator John Barrasso (R-WY) and Senator Mike Braun (R-IN) that spurred the Nuclear Regulatory Commission (NRC) develop a generic environmental impact statement (GEIS) for the construction and operation of advanced reactors.[17] The NRC expanded the applicability of the GEIS to all new reactors that meet the "values and the assumptions of the plant parameter envelopes and the site parameter envelopes

---

[8] *Wyoming Trona*, Wyoming State Geological Survey (2024), available at: https://main.wsgs.wyo.gov/mineral-resources/industrial-minerals/trona.

[9] Renee Jean, *Going Underground in one of Wyoming's Trona Mines*, Cowboy State Daily, (November 23, 2023) available at: https://cowboystatedaily.com/2023/11/23/producing-90-of-us-trona-theres-a-piece-of-wyoming-in-every-kitchen-in-america/.

[10] *Wyoming's Trona Mining and Sodium-Based Chemical Manufacturing* (hereinafter "Trona Guide"), Wyoming Mining Association, 2-3, (2020) available at: https://www.wyomingmining.org/wp-content/uploads/2013/10/200210-Trona-Guide.pdf.

[11] Trona, Wyoming Mining Association website (2024) available at: https://www.wyomingmining.org/minerals/trona/ (last accessed on December 15, 2024.)

[12] *See Wyoming Trona supra* note 8.

[13] Jean *supra* note 11.

[14] *See* Trona *supra* note 13.

[15] *See id*.

[16] *Tata Chemicals Soda Ash Partners LLC Signs Agreement with BWXT to Identify Path Forward for Industrial Commercial Nuclear Reactors in Wyoming*, Tata Chemicals North America Press Release (September 18, 2023) available at: https://www.tatachemicals.com/upload/content_pdf/2023-tata-bwxt-agreement-ftfr.pdf.

[17] *Barrasso & Braun Call on NRC to Assist Permitting for Advanced Nuclear Projects*, Minority News, U.S. Senate Committee on Environment and Public Works (June 25, 2019) https://www.epw.senate.gov/public/index.cfm/press-releases-republican?ID=A71D508F-615E-4F5D-845C-FD489D8219BF.

used to develop the GEIS."[18] At the time of drafting this article, the GEIS rulemaking was open for public comment.[19] Final publishing of the GEIS has the potential to significantly streamline the National Environmental Policy Act (NEPA) analysis requirements for new reactor projects in Wyoming and across the country and could reduce costs for such future analysis by 20 to 45 percent.[20]

At home, the Wyoming legislature created the WEA in 2019 to "[d]iversify and expand Wyoming's economy through improvements in the state's electric energy transmission infrastructure and facilitate Wyoming's production, development and transmission of energy and associated natural resources."[21] In 2022 and 2023, the legislature appropriated a total of $150 million in energy matching funds to the Office of the Governor "for the purposes of providing matching funds for private or federal funding for research, demonstration, pilot projects or commercial deployment projects related to Wyoming energy needs."[22] Governor Gordon delegated management of the energy matching funds to the WEA and, in addition to the BWXT project, these funds have been utilized to fund various carbon capture, utilization, and storage, hydrogen production, enhanced oil recovery, and advanced wind energy generation projects.[23]

The Wyoming legislature has also sought to reduce the regulatory burden on the deployment of advanced reactors in the State. Wyo. Stat. Ann. § 35-11-2101 limits the application of the provisions of the Wyoming Industrial Development Information and Siting Act ("Industrial Siting Act") to those that "do not interfere with, contradict or dispute any requirements of the United States Nuclear Regulatory Commission."[24] The Industrial Siting Act would apply to any advanced reactor project with an estimated construction cost of $283,166,876 or more.[25] Industrial Siting permit applications are extensive, often requiring multiple seasons of environmental studies, and include public notice requirements along with a potentially adversarial public hearing requirement.[26] Narrowing the scope of what is subject to Industrial Siting Council review is meaningful and demonstrates a commitment from the Wyoming legislature to the deployment of advanced reactors in the state, including microreactors such as BANR.[27]

BANR and What Comes Next

BWXT describes BANR as modular 50 MWt high-temperature gas reactor that provides "flexible options for energy output – including electricity, steam for process heat, or both in a mode called 'cogeneration.'"[28] BANR's 50 MWt energy output puts it on the higher end of the energy output spectrum for a microreactor, but BANR meets the characteristics the U.S. Department of Energy (DOE) uses to define a microreactor.[29] First,

[18] New Nuclear Reactor Generic Environmental Impact Statement (NR GEIS), U.S. Nuclear Regulatory Commission website (last updated October 29, 2024) available at: https://www.nrc.gov/reactors/new-reactors/advanced/modernizing/rulemaking/advanced-reactor-generic-environmental-impact-statement-geis.html.

[19] *Id*.

[20] *NIA Statement on NRC Commission Vote on Advanced Nuclear Reactor Generic Environmental Impact Statement*, Nuclear Innovation Alliance Blog Post (April 24, 2024) available at: https://nuclearinnovationalliance.org/nia-statement-nrc-commission-vote-advanced-nuclear-reactor-generic-environmental-impact-statement.

[21] See Wyo. Stat. §§ 37-5-501 – 37-5-607. This statute merged the Wyoming Infrastructure Authority, Wyoming Pipeline Authority and the State Energy Office into one multi-discipline authority.

[22] 2022 General Appropriations Bill, 2022 Wyoming Session Law Chapter 51, Section 321(a) (appropriating $100 million to the office of the governor.) Another $50 million was appropriated in 2023. *See* 2023 Supplemental General Appropriations Bill, 2023 Wyoming Sessions Law Chapter 94, Section 321(a).

[23] Energy Matching Funds, Wyoming Energy Authority Website (last accessed on December 15, 2024) available at: https://wyoenergy.org/energy-matching-funds/.

[24] Wyo. Stat. Ann. § 35-11-2101(e).

[25] Wyo. Stat. Ann § 35-12-102(a)(vii) establishes a construction cost threshold of $96,900,000.00 in 1987 dollars, which the Industrial Siting Division calculates in today's dollars to be $283,166,876. *See* Jurisdictional Information, Wyoming Industrial Siting Permitting website available at: https://deq.wyoming.gov/industrial-siting-2/permitting/.

[26] *See* Wyo. Stat. Ann. §§ 35-12-110 – 35-12-112.

[27] TerraPower submitted a nearly 1,500-page Industrial Siting Permit Application on October 24, 2024, and it is currently under review. The application is publicly available on the Industrial Siting Division's website at: https://drive.google.com/file/d/19i2iEdmw_IVUBQL-8J3Dk35Rd4aOJ2Jx/view.

[28] Terrestrial Micro RX, BWX Technologies, Inc. website (last visited on December 15, 2024) available at: https://www.bwxt.com/what-we-do/advanced-technologies/terrestrial-micro-rx.

[29] *What is a Nuclear Microreactor?*, U.S. Department of Energy, Office of Nuclear Energy Blog (February 26, 2021) https://www.energy.gov/ne/articles/what-nuclear-microreactor.

BANR employs a mature, factory manufacturable high-temperature gas reactor technology.[30] Second, it employs a modular design that is light enough to be transported via rail, ship, or truck.[31] Finally, BANR utilizes inherent safety features, high power-density fuel, and can be operated with reduced staffing.[32] Below is a rendering of a single BANR reactor housed in a simple concreate structure. The manufacturability of BANR, combined with the relatively simple civil construction work associated with deploying a reactor or group of reactors, should reduce overall project cost and increase predictability of such costs, especially as more reactors are manufactured (see Figure 2 at end of this article – BWXT BANR site rendering).

The civil construction work required for microreactors and some small-modular reactor (SMR) designs is much different than the large containment structures required by the existing LWR. One reason that large containment structures are not required is because the fissile material is contained within the fuel form itself. For example, BANR is designed to utilize Tri-structural Isotropic particle fuel (TRISO), which the DOE describes as the most robust nuclear fuel in the world.[33] Individual TRISO particles are no larger than a poppy seed and they can be fabricated into cylindrical pellets or spherical "pebbles" that can be used in high temperature gas reactors or molten salt-cooled reactors.[34]

TRISO gets its name from the fact that each kernel of uranium is surrounded by an inner pyrolytic carbon graphite layer that allows for expansion and contraction of the uranium kernel as it heats up and cools, and three protective carbon layers.[35] These layers include an inner and outer pyrolytic carbon layer with a structural silicon carbide layer sandwiched in between.[36] TRISO technology was developed in the 1960s and the particles have been tested at temperatures up to 1,800 degrees Celsius, over 3,000 degrees Fahrenheit, with no to minimal particle damage.[37] These temperatures exceed the predicted worst-case accident conditions for a high-temperature gas reactor like BANR.[38] The Department of Defense has selected TRISO fuel for its microreactor program and commercial reactors from X-energy and Kairos Power, among others, are planning to use TRISO fuel in their advanced reactor designs.[39]

A BANR reactor's minimal footprint, inherent safety features, and capability of operating in cogeneration mode, could provide industrial users with a reliable and resilient source of behind the meter electricity and industrial heat. The WEA and BWXT have progressed into Phase 2 of their contract, which includes "completing conceptual design of a lead microreactor unit, developing a regulatory engagement plan and microreactor fleet model, and demonstrating the Wyoming supply chain's ability to manufacture nuclear components."[40] A month after progressing into Phase 2 of its WEA contract, BWXT announced that it had signed a new cooperative agreement with WEA, with no funding from the WEA attached, to evaluate the siting of a TRISO fuel fabrication facility in Wyoming.[41] Tata Chemicals' signed letter of intent has now established an early 2030s timeline for deploying BANRs at a Wyoming trona mine, which in-turn means that there will be a need for a significant amount of TRISO fuel for those reactors and others in development.

Challenges and Opportunities

Wyoming has the opportunity to become home to one of the nation's first commercial microreactor deployments. Whether that opportunity will materialize will depend heavily on whether the economics make sense. The benefits of a micro-nuclear reactor versus other forms of self-generation for an industrial user include a long fuel

---

[30] Terrestrial Micro RX, *supra* note 29.
[31] *Id*.
[32] *Id*.
[33] *TRISO Particles: The Most Robust Nuclear Fuel on Earth*, U.S. Department of Energy, Office of Nuclear Energy Blog (July 9, 2019 (updated June 2023)) https://www.energy.gov/ne/articles/triso-particles-most-robust-nuclear-fuel-earth#:~:text=What%20is%20TRISO%20Fuel%3F,release%20of%20 radioactive%20fission%20products.
[34] *Id*.
[35] *TRISO Fuel The Future of Nuclear*, BWX Technologies Inc., (2023) available at: https://www.bwxt.com/media/3802c32b-505d-43fb-a5b6-48d8869edfec/iHTYEQ/Documents/ Literature/TRISO%20Fuel.pdf.
[36] *Id*.
[37] *TRISO Particles: The Most Robust Nuclear Fuel on Earth supra* note 35.
[38] *Id*.
[39] *Id*.
[40] *BWXT Awarded Phase Two of Microreactor Evaluation Contract for State of Wyoming*, Wyoming Energy Authority Press Release (June 17, 2024) available at: https://wyoenergy.org/bwxt-phase-2-contract/.
[41] *BWXT to Evaluate Locations for Building New Nuclear TRISO Fuel Production Facility to Support Advanced Reactor Deployment*, BWX Technologies, Inc. News (July 18, 2024) available at: https://www.bwxt.com/news/2024/07/18/BWXT-to-Evaluate-Locations-for-Building-New-Nuclear-TRISO-Fuel-Production-Facility-to-Support-Advanced-Reactor-Deployment.

cycle, a smaller footprint than similarly powered non-carbon emitting energy sources, and they are expected to be efficient and resilient. BANR is expected to operate on a five-year fuel cycle[42] and a report by the Nuclear Energy Institute estimates that microreactors are expected to operate at a capacity factor of 95% or more.[43] The Tata Chemicals' press release announcing the letter of intent to deploy BANR reactors to support trona mining operations explains that one of the next steps is to determine the "techno-economic parameters necessary to turn conditional reactor purchase commitments into an energy purchase agreement."[44] How Wyoming law defines public utilities and the statutory limitations on behind the meter self-generation currently leaves some uncertainty as to what options are available to Tata Chemicals and BWXT in the form of an energy purchase agreement.

Under Wyoming law, a public electrical utility is defined as: "[a]ny plant, property or facility for the generation, transmission, distribution, sale or furnishing to or for the public of electricity for light, heat or power."[45] The statute exempts from regulation as a utility those electricity producers who produce electricity for the sole use of the producer and tenants of the producer "and not for sale to others."[46] Arguably, a microreactor or cluster of microreactors owned by an operating company which are installed specifically to sell the heat and electricity produced by those reactors to one or a small number of industrial users is not furnishing or selling electricity "to or for the public." There is Wyoming case law that would support this position, but this specific question has not been addressed by the Courts in the context of the provision of electricity to end users.

In the 2009 case *Krenning v. Heart Mt. Irrigation Dist.*, the Wyoming Supreme Court reiterated its prior precedent that the "statutory phrase 'to and for the public' refers to 'sales to sufficient of the public to clothe the operation with a public interest.'"[47] The test, according to the Court, is "not the absolute number of persons [an entity] serves, but whether it is devoted to public use."[48] What matters in determining whether an entity is devoted to public use is 1) whether the entity "solicited practically everyone in that territory" and 2) whether the entity "accepted substantially all requests for services of its commodity."[49] The *Krenning* Court found that an irrigation district that served a limited subset of the public at large was not a public utility, and analogized this finding with a prior ruling that an electric company supplying electricity to a limited number of distributors was not a public utility.[50]

The distinction between what is and what is not a public utility matters. The Wyoming PSC regulates monopoly public utilities to ensure the utilities provide safe, adequate and reliable service at just and reasonable prices.[51] A reactor operating company providing heat and electricity via negotiated power purchase agreements or similar arrangements to one or more industrial users is not what the PCS or its regulations are designed to regulate. Wyoming statutes clearly authorize an industrial user to produce electricity for its own and its tenants' consumption without being regulated as a public utility. Under Wyoming case law an industrial user or group of industrial users should also be able to contract with an energy producer to provide heat and electricity, so long as the energy producer does not solicit practically all potential customers in the area and does not accept substantially all requests for its services. But the ability for industrial users to contract for their own power needs flies in the face of the monopoly public utilities construct and could be seen by such utilities as an existential threat. The Wyoming PSC has recently published draft rules for regulating what it calls "non-public utility generators," and is in the process of evaluating the public comments and stakeholders' concerns with the draft rules.[52] The rules, as currently

---

[42] Terrestrial Micro RX, supra note 29.

[43] *Cost Competitiveness of Micro-Reactors for Remote Markets*, Nuclear Reactor Institute Report, p. 2 (April 15, 2019) available at: https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/Report-Cost-Competitiveness-of-Micro-Reactors-for-Remote-Markets.pdf.

[44] *Tata Chemicals North America announces Letter of Intent (LOI) with BWXT to explore the deployment of eight BWXT Advanced Nuclear Reactors (BANR) in Wyoming*, Tata Chemicals Soda Ash Partners LLC Press Release (December 12, 2024) available at: https://www.tatachemicals.com/upload/content_pdf/BWXT-Tata-LOI-12-December-2024.pdf.

[45] Wyo. Stat. Ann. § 37-1-101(a)(vi)(C).

[46] *Id*. at § 37-1-101(a)(vi)(H)(VI).

[47] *Krenning v. Heart Mt. Irrigation Dist.*, 200 P.3d 774, 782 (Wyo. 2009) (quoting *Phillips Petroleum Co. v. Public Service Comm'n of Wyoming*, 545 P.2d 1167, 1171 (Wyo. 1976)).

[48] *Id.* (citing to *Rural Elec. Co. v. State Bd. of Equalization*, 120 P.2d 741, 747 (Wyo. 1942)).

[49] *Id*. (quoting *Rural Elec. Co. v. State Bd. of Equalization*, 120 P.2d at 751.)

[50] *Id.* (citing to *Bridle Bit Ranch Co. v. Basin Elec. Power Coop.*, 118 P.3d 996, 1011 (Wyo. 2005).)

[51] Wyoming Public Service Commission website available at: https://psc.wyo.gov/about-us.

[52] Notice of Intent to Adopt Rules, Wyoming Public Service Commission, available at: https://wyoleg.gov/arules/2012/rules/ARR24-080P.pdf.

drafted, would make it extremely difficult for a non-public utility generator to be authorized by the PSC, because it would require a finding of no material harmful effect on the local utility.[53] A more fundamental problem with the draft rules is that they grant the PSC authority over entities that are by definition not public utilities.

There may be opportunities for utilities to leverage their experience and support industrial users' desire to have dedicated, reliable, and resilient generation assets available to them without actually owning and operating the assets. Utilities could prove to be very effective operating companies. They could provide such a service for industrial users within their territory who are interested in making the investment into dedicated behind the meter generation assets but want to have another entity own and operate the assets. Regardless, there are a number of reasons why an industrial user may prefer, or need, a third-party entity to own and operate the microreactors that provide for their energy needs. In the case of Tata Chemicals, the Atomic Energy Act and NRC regulations prohibit the issuance of an NRC license to a corporation or entity that is owned, controlled, or dominated by a foreign corporation.[54] Tata Chemicals' parent company, Tata Group, is an Indian company with operations around the globe.[55] In fact, three of the four trona mines in Wyoming are owned by foreign companies.[56]

Conclusion

Rapidly increasing energy demands, transmission constrictions, and the market's demand for more non-carbon emitting energy sources may be the convergence of factors necessary for the current nuclear renaissance to become a reality. Wyoming has positioned itself to be home to the first grid scale advanced reactor and the first microreactor deployment to an industrial site in the United States. Investment by the Wyoming legislature, through the WEA, has resulted in a partnership that is now working to develop a supply chain for advanced reactor parts in Wyoming and potentially even the construction of an advanced reactor fuel fabrication facility. Challenges remain and BWXT and Tata Chemicals will have to work through those challenges as they develop the terms and conditions of the energy purchase agreement, and there are still NRC licenses that have yet to be issued. But these are not insurmountable challenges, and Wyoming has shown a strong commitment, at every level of government, to being a leader in advanced nuclear reactor development and deployment. Wyoming industry and local leaders around the state have also embraced nuclear energy and the opportunity to build a supply chain for advanced reactors in the State. These commitments should help Wyoming continue to be a leader in the "all-of-the-above" energy space for decades to come.

(see Figure 1 and Figure 2 on next page)

[53] *Id*.
[54] *See* Atomic Energy Act, Sec. 103d, 42 U.S.C. 2133(d) (1954) and 10 C.F.R. § 50.38.
[55] See Tata Group website available at: https://www.tata.com/business/overview.
[56] Solvay USA Inc. is owned by the Belgian company Solvay and Sisecam Wyoming LLC is owned by the Turkish company Sisecam.

Figure 1 - Trona refining process.[1]

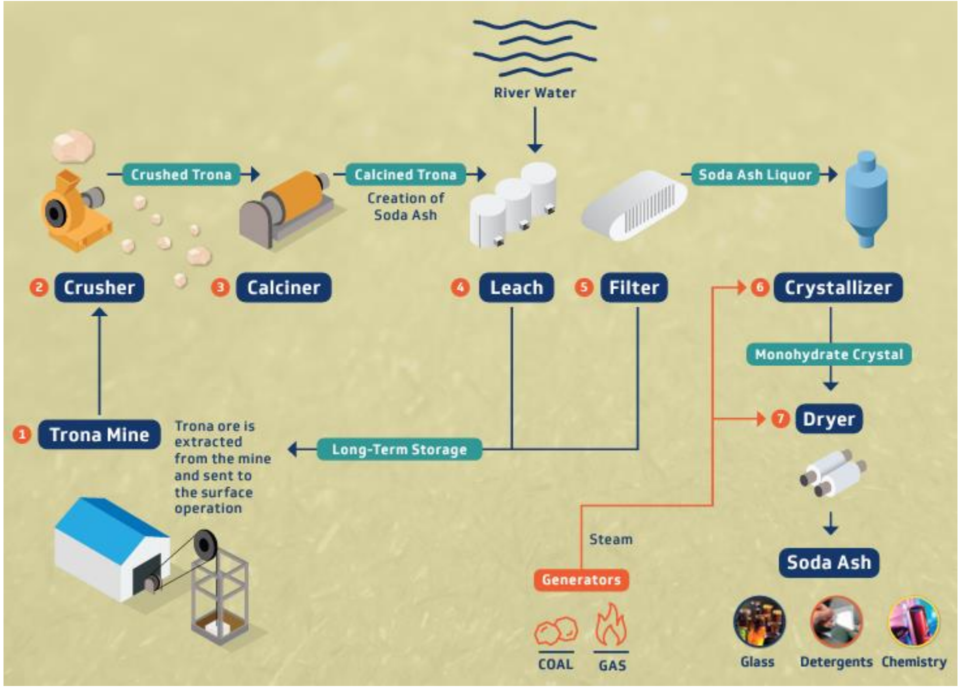
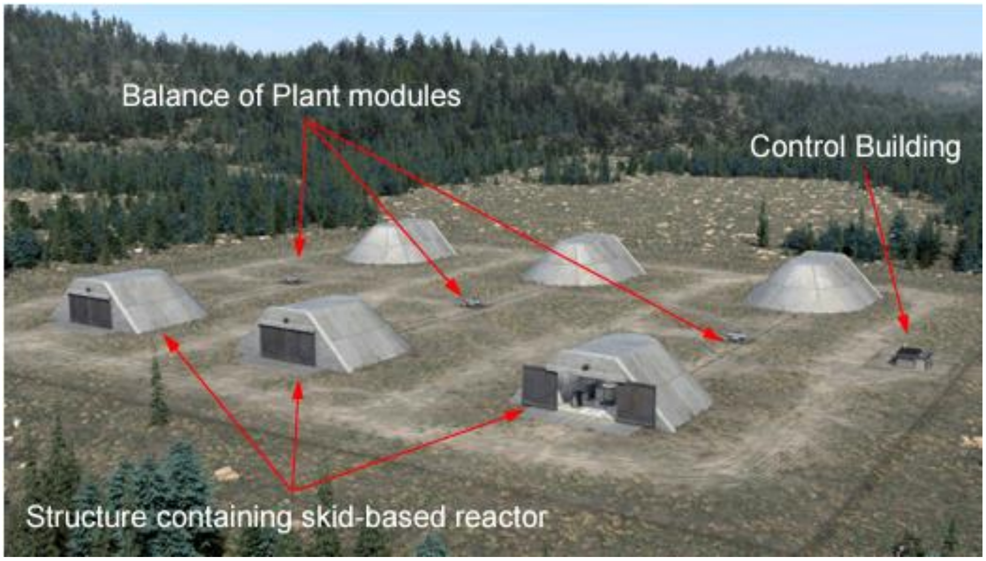


Figure 2, BWXT BANR site rendering.[2]



[1] BWXT Advanced Nuclear Reactor (BANR) Regulatory Update, slide 7 (June 6, 2023) available at: https://www.nrc.gov/docs/ML2315/ML23156A226.pdf.
[2] *Id*.

SHOULD THE U.S. WAIT TO CONSOLIDATE?
RECENT LEGAL DEVELOPMENTS REGARDING THE INTERIM STORAGE OF NUCLEAR WASTE*

Scarlett Forrest *(author)*
Tara Righetti and Madeleine Lewis *(reviewers)*
University of Wyoming
Laramie, Wyoming

*Authored by Scarlett Forrest and reviewed by Tara Righetti and Madeleine Lewis. Scarlett Forrest is a Jurisprudence of Underground Law & Energy (JOULE) Research Scientist at the University of Wyoming School of Energy Resources. She received her B.S. in Environmental Science from Virginia Tech in 2016 and worked at an environmental consulting and engineering firm for five years before pursuing a law degree at the University of Wyoming. She received her J.D. from the University of Wyoming College of Law in May 2024, and is a licensed attorney in Colorado. Tara Righetti is the Occidental Chair of Energy and Environmental Policies, the co-director of the Nuclear Energy Research Center at the University of Wyoming, and the co-director of JOULE at the University of Wyoming School of Energy Resources. Madeleine Lewis, JD/MA, is a JOULE research scientist and lecturer at the University of Wyoming School of Energy Resources.

I. Introduction

The United States' unrelenting nuclear waste storage problem made headlines again when, in October 2024, the U.S. Supreme Court accepted review of two cases related to the Nuclear Regulatory Commission's (NRC)'s decision to license interim storage facilities.[1] The circumstances leading up to this litigation began when the NRC received two separate applications from private entities to build away-from-reactor Consolidated Interim Storage Facilities (CISFs) in Texas and New Mexico.[2] A CISF is a facility designed and licensed to accept and store radioactive nuclear waste from operating and decommissioned reactor sites until it can be transferred to a permanent repository.[3]

Storing nuclear waste is essential to nuclear energy production. Commercial nuclear power plants generate high-level,[4] radioactive waste composed of "spent" uranium or plutonium fuel, meaning the fuel is no

[1] *See e.g.*, Greg Stohr, *Nuclear Waste Storage Site in Texas Draws Supreme Court Review*, BLOOMBERG NEWS, Oct. 4, 2024; Mark Sherman, *Supreme Court Steps into a Fight Over Plans to Store Nuclear Waste in Rural Texas and New Mexico,* ASSOC. PRESS, Oct. 4, 2024; Nate Raymond, *US Supreme Court to Hear Nuclear Waste Storage Dispute*, REUTERS, Oct. 4, 2024.

[2] The NRC received these applications in 2016 and 2017 for the CISFs proposed in Texas and New Mexico, respectively. Storage of Spent Nuclear Fuel, U.S. NUCLEAR REGUL. COMM'N, https://www.nrc.gov/waste/spent-fuel-storage.html (last updated Aug. 28, 2024).

[3] The benefit of a CISF accepting waste from a decommissioned reactor site is that removing the waste makes the land at these sites available for other uses. U.S. NUCLEAR REGUL. COMM'N, NUREG-2237, ENVIRONMENTAL IMPACT STATEMENT FOR THE HOLTEC INTERNATIONAL'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN LEA COUNTY, NEW MEXICO (2022); U.S. NUCLEAR REGUL. COMM'N, NUREG-2239, ENVIRONMENTAL IMPACT STATEMENT FOR INTERIM STORAGE PARTNERS LLC'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN ANDREWS COUNTY, TEXAS (2021). CISFs are a type of Independent Spent Fuel Storage Installation or ISFSI, defined in NRC regulations as "a complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related GTCC waste, and other radioactive materials associated with spent fuel and reactor-related GTCC waste storage. An ISFSI which is located on the site of another facility licensed under this part or a facility licensed under part 50 of this chapter and which shares common utilities and services with that facility or is physically connected with that other facility may still be considered independent." *See* 10 C.F.R. § 72.3 (2023).

[4] Broadly, there are two classifications of nuclear waste: high-level and low-level. U.S. NUCLEAR REGUL. COMM'N, OFF. OF PUB. AFF., BACKGROUNDER ON RADIOACTIVE WASTE 1 (2024) ("High-level waste is primarily spent fuel removed from reactors after producing electricity. Low-level waste comes from reactor operations and from medical, academic, industrial, and other commercial uses of radioactive materials.") However, the NRC, states, and the nuclear industry can associate different meanings to the same terms, and for the sake of clarity, this article will follow the NRC's definitions in its regulations. Please note that the NRC has technically differentiated high-level radioactive waste from SNF. *See* 10 C.F.R. § 72.3 (2023) (defining high-level radioactive waste as "(1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel,

longer capable of efficiently producing electricity.[5] This waste is known as spent nuclear fuel (SNF).[6] SNF poses significant technical, regulatory, and political challenges for its safe storage and disposal because of the hazards it poses to human health and health and the environment.[7] SNF is thermally hot and requires between two and five years to remove the initial intense heat generated by radioactive decay.[8] It is also highly radioactive and takes several hundred thousand years to radioactively decay to the same level as the uranium "ore from which the fuel was originally mined."[9] When SNF is removed from the reactor, it is six orders of magnitude more radioactive than the original uranium fuel.[10] Someone exposed to this level of radiation would absorb a lethal dose in less than a minute.[11] These attributes make transportation and handling of SNF difficult immediately following removal from the reactor core, necessitating initial storage onsite in spent fuel pools or in "dry cask" storage until the SNF radioactively decays and cools down enough for transfer into interim or permanent storage.[12]

The current challenge, however, is that neither CISFs nor a permanent repository exists in the U.S., so nuclear power plants must indefinitely store SNF onsite.[13] Onsite storage was never intended as a permanent solution.[14] Scientists estimate that SNF will be radioactive at a much safer and lower level after one million years, and therefore disposal options must be viable for up to one million years.[15] Accordingly, while onsite storage is designed to safely store SNF over the span of several decades, it is not a technically viable long-term solution.[16] Due to the repeated failure of previous efforts to locate and construct a permanent repository capable of storing SNF for millennia, by default, all SNF in the U.S. is currently in onsite "interim storage," or is being stored "pending the availability of a long-term disposal option."[17]

---

including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (2) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation" and SNF as "fuel that has been withdrawn from a nuclear reactor following irradiation, has undergone at least one year's decay since being used as a source of energy in a power reactor, and has not been chemically separated into its constituent elements by reprocessing. Spent fuel includes the special nuclear material, byproduct material, source material, and other radioactive materials associated with fuel assemblies.")

[5] U.S. NUCLEAR REGUL. COMM'N, OFF. OF PUB. AFF., BACKGROUNDER ON RADIOACTIVE WASTE 1 (2024).

[6] *See* 10 C.F.R. § 72.3 (2023); *See also*; Dylan Cohen, Note, *Temporary Nuclear Waste Siting is a Major Problem But Not a Major Question*, 13 MICH. J. ENVTL. & ADMIN. L. 179, 183-84 (2023).

[7] U.S. NUCLEAR REGUL. COMM'N, OFF. OF PUB. AFF., BACKGROUNDER ON RADIOACTIVE WASTE 1 (2024).

[8] Plutonium-239 has a half-life of 24,000 years. U.S. NUCLEAR REGUL. COMM'N, OFF. OF PUB. AFF., BACKGROUNDER ON RADIOACTIVE WASTE 2 (2024). SNF is also susceptive to corroding in the presence of oxygen, making storage and disposal challenging. Claire Corkhill & Neil Hyatt, NUCLEAR WASTE MANAGEMENT 9 (2018).

[9] Claire Corkhill & Neil Hyatt, NUCLEAR WASTE MANAGEMENT 4 (2018).

[10] *Id*. at 9.

[11] *Id*.

[12] *Id*. Spent fuel pools are designed to cool the spent rods under water and provide a shield against the radiation. Once the pools are nearly filled to capacity with SNF, utilities move some of the older SNF into "dry cask" storage. "Dry cask" storage "allows spent fuel that has already been cooled in the spent fuel pool for at least one year to be surrounded by inert gas inside a container called a cask. The casks are typically steel cylinders that are either welded or bolted closed. The steel cylinder provides a leak-tight confinement of the spent fuel." Dry Cask Storage, U.S. NUCLEAR REGUL. COMM'N, https://www.nrc.gov/waste/spent-fuel-storage/dry-cask-storage.htmlhttps://www.nrc.gov/waste/spent-fuel-storage.html (last updated June 16, 2023).

[13] Claire Corkhill & Neil Hyatt, NUCLEAR WASTE MANAGEMENT 4 (2018).

[14] Allison MacFarlane & Rodney C. Ewing, *Nuclear Waste Is Piling Up. Does the U.S. Have a Plan*?, SCI. AM., (Mar. 6, 2023) ("Storing [SNF] in pools and dry casks at reactor sites is a temporary solution; it is safe for decades, but not the millennia needed to isolate this radioactive material from the environment."); *see also* Dylan Cohen, Note, *Temporary Nuclear Waste Siting is a Major Problem But Not a Major Question*, 13 MICH. J. ENVTL. & ADMIN. L. 179, 184-85 (2023).

[15] Claire Corkhill & Neil Hyatt, NUCLEAR WASTE MANAGEMENT 4 (2018).

[16] According to one former NRC Chair: "We don't know how many decades. We don't think they'll last for hundreds of years…[s]o, this is not a long-term solution." Alan Yu, *Where can the U.S. put 88,000 tons of nuclear waste?*, WHYY, June 26, 2023.

[17] The Nuclear Fuel Cycle: Storage and Disposal of Radioactive Waste, WORLD NUCLEAR ASSOC., https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste#interim-waste-storage-and-transport (last updated Apr. 24, 2024); *see also* Max Johnson, Note, *Defining Interim Storage of Nuclear Waste*, 117 NW. U. L. REV. 1177, 1197-98 (2023).

Not only is onsite storage an imperfect solution, it is also an expensive one costing American taxpayers. In the 1980s, Congress directed the DOE to enter into contracts committing the agency to taking custody of SNF generated from private utilities for storage and disposal in a permanent federal repository.[18] However, without a permanent repository, the DOE cannot take custody of the SNF.[19] As a result, utilities have had to continue managing and storing the SNF they generate onsite.[20] As of September 2023, the federal government has paid $10.6 billion to reimburse the utility companies for storage costs they otherwise would not have incurred had DOE complied with its obligations under the contracts.[21] As long as no alternatives to onsite interim storage exists, that number will continue to grow. Even with a permanent disposal facility, it could still take decades for the DOE to take custody of the nation's spread out SNF inventory.[22]

Alternatively, CISFs could provide several benefits as compared to onsite interim storage. First and foremost, CISFs provide the means to consolidate and centralize the SNF backlog.[23] Doing so could benefit the U.S.'s SNF waste management system in multiple ways, including: allowing the federal government to accept SNF earlier than the establishment of a permanent repository;[24] providing an alternative to the "continued unintended and unplanned growth of an ad hoc, decentralized, long-term storage system at reactor sites by default";[25] freeing up decommissioned reactor sites for other uses;[26] and adding flexibility and the necessary infrastructure for integrated, large-scale SNF management.[27] Yet, CISFs, too, are intended only as an interim storage solution. However, like onsite SNF storage, in the absence of permanent disposal options, CISFs "threaten to become de facto permanent disposal facilities."[28]

These concerns have resulted in opposition to CISF facilities in the two states where they have been proposed and licensed. During the NRC's licensing process, the Texas Commission on Environmental Quality and the governor of Texas submitted comments to the NRC

[18] JASON O. HEFLIN, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 3 (2024); U.S. GOV'T ACCOUNTABILITY OFF., GAO-11-229, COMMERCIAL NUCLEAR WASTE: EFFECTS OF A TERMINATION OF THE YUCCA MOUNTAIN REPOSITORY PROGRAM AND LESSONS LEARNED 2 (2011).

[19] JASON O. HEFLIN, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 2 (2024); U.S. GOV'T ACCOUNTABILITY OFF., GAO-11-229, COMMERCIAL NUCLEAR WASTE: EFFECTS OF A TERMINATION OF THE YUCCA MOUNTAIN REPOSITORY PROGRAM AND LESSONS LEARNED 31 (2011).

[20] *Id.*

[21] U.S. GOV'T ACCOUNTABILITY OFF., GAO-11-229, COMMERCIAL NUCLEAR WASTE: EFFECTS OF A TERMINATION OF THE YUCCA MOUNTAIN REPOSITORY PROGRAM AND LESSONS LEARNED 30-31 (2011).

[22] U.S. GOV'T ACCOUNTABILITY OFF., GAO-11-229, COMMERCIAL NUCLEAR WASTE: EFFECTS OF A TERMINATION OF THE YUCCA MOUNTAIN REPOSITORY PROGRAM AND LESSONS LEARNED 30-31 (2011).

[23] U.S. DEP'T OF ENERGY, NL/RPT-21-64973, SPENT FUEL AND WASTE DISPOSITION: SUMMARY OF CONSOLIDATED INTERIM STORAGE ADVANTAGES AND DISADVANTAGES FROM AN INTEGRATED SYSTEMS PERSPECTIVE FROM PRIOR REPORTS AND STUDIES iii (2023); U.S. NUCLEAR REGUL. COMM'N, NUREG-2237, ENVIRONMENTAL IMPACT STATEMENT FOR THE HOLTEC INTERNATIONAL'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN LEA COUNTY, NEW MEXICO (2022); U.S. NUCLEAR REGUL. COMM'N, NUREG-2239, ENVIRONMENTAL IMPACT STATEMENT FOR INTERIM STORAGE PARTNERS LLC'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN ANDREWS COUNTY, TEXAS (2021).

[24] U.S. DEP'T OF ENERGY, NL/RPT-21-64973, SPENT FUEL AND WASTE DISPOSITION: SUMMARY OF CONSOLIDATED INTERIM STORAGE ADVANTAGES AND DISADVANTAGES FROM AN INTEGRATED SYSTEMS PERSPECTIVE FROM PRIOR REPORTS AND STUDIES 6-7 (2023).

[25] *Id.* at 8.

[26] U.S. NUCLEAR REGUL. COMM'N, NUREG-2237, ENVIRONMENTAL IMPACT STATEMENT FOR THE HOLTEC INTERNATIONAL'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN LEA COUNTY, NEW MEXICO (2022); U.S. NUCLEAR REGUL. COMM'N, NUREG-2239, ENVIRONMENTAL IMPACT STATEMENT FOR INTERIM STORAGE PARTNERS LLC'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN ANDREWS COUNTY, TEXAS (2021).

[27] U.S. DEP'T OF ENERGY, NL/RPT-21-64973, SPENT FUEL AND WASTE DISPOSITION: SUMMARY OF CONSOLIDATED INTERIM STORAGE ADVANTAGES AND DISADVANTAGES FROM AN INTEGRATED SYSTEMS PERSPECTIVE FROM PRIOR REPORTS AND STUDIES 10-11 (2023).

[28] Allison MacFarlane & Rodney C. Ewing, *Nuclear Waste Is Piling Up. Does the U.S. Have a Plan*?, SCI. AM., (Mar. 6, 2023); Max Johnson, Note, *Defining Interim Storage of Nuclear Waste,* 117 NW. U. L. REV. 1177, 1197-98 (2023) ("…the duration of that interim storage is completely unknowable—and potentially permanent.").

on its draft Environmental Impact Statement (EIS) expressing concerns that licensing the CISF could "result in the State of Texas becoming the permanent solution" for nuclear waste disposal.[29] When the NRC issued its final EIS revealing its preferred choice to move forward with licensing the Texas CISF, Texas responded by passing a law in August 2021 that prohibited the construction and development of new nuclear waste storage facilities in the state.[30] The NRC then granted a license for the proposed Texas CISF the following September.[31] For the CISF proposed in New Mexico, environmental and private industry groups attempted to intervene in the NRC's licensing proceeding, which the NRC denied.[32] These groups then petitioned the D.C. Circuit to review the NRC's orders denying their petitions to intervene and while the litigation was pending, the NRC licensed the New Mexico CISF in May 2023.[33] The controversy over the two licenses has spurred multiple cases, united strange bedfellows against the NRC, and has been heard in the Fifth, Tenth, and D.C. Circuits.[34] The two issues ultimately before the Supreme Court are: 1) Who can challenge NRC licensing decisions in Federal Court; and 2) Whether the NRC has the authority to issue licenses for away-from-reactor, private CISFs.[35]

The first issue highlights a circuit split interpreting the Hobbs Act. The Hobbs Act gives federal courts of appeals exclusive jurisdiction over certain final agency orders, including NRC orders, and allows "[a]ny party aggrieved" by a final order to petition a court of appeal for review.[36] The Tenth and D.C. Circuits have determined that parties must attempt to intervene or be admitted as a party in NRC licensing proceedings to qualify as a "party aggrieved" under the Hobbs Act.[37] Specifically, the Tenth Circuit ruled in *Balderas v. NRC,* that parties who could have petitioned to intervene in the NRC licensing proceeding but did not do so, do not qualify as a "party aggrieved."[38] The Tenth and D.C. Circuits also explicitly declined to adopt the Fifth Circuit's 1981 *American Trucking Associations, Inc. v. I.C.C* holding that a person or entity who was not a party to the underlying agency proceeding may petition for review of the agency action if that action exceeded its authority.[39] This is known as the "*ultra vires*" exception to the Hobbs Act's party aggrieved limitation on review.[40] In contrast, however, in *Texas v. NRC,* the Fifth Circuit determined that a party submitting comments in an NRC proceeding likely qualifies as a "party aggrieved."[41] However, relying on its *American Trucking Associations* precedent, the court found the question of whether the petitioner was a "party aggrieved" irrelevant because the petition challenged the agency action as *ultra vires*.[42]

---

[29] JASON O. HEFLIN, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 3 (2024).

[30] This Texas law is known as H.B. 7, which makes it illegal to dispose of or store high level radioactive waste in Texas "other than former nuclear power reactors and former nuclear research and test reactors on university campuses[.]"TEX. HEALTH & SAFETY CODE ANN. § 401.072 (West 2024); *see also* Erin Douglas, *Texas bans storage of highly radioactive waste, but a West Texas facility may get a license from the feds anyway*, TEX. TRIB., Sept. 30, 2021; *Texas v. Nuclear Regul. Comm'n*, 78 F.4th 827, 834 (5th Cir. 2023); Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 3 (2024).

[30] *Id.*

[31] Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 3 (2024).

[32] *Id.* at 4-5.

[33] *Id.*

[34] The unlikely allies that united against the NRC include environmental groups, the state of Texas, and an oil and gas extraction organization. *State ex rel. Balderas v. Nuclear Regul. Comm'n*, 59 F.4th 1112, 1116-1118 (10th Cir. 2023); *Don't Waste Mich. v. Nuclear Regul. Comm'n*, No. 21-1048, 2023 WL 395030, at *2-*3 (Jan. 25, 2023) (per curiam); *Texas v. Nuclear Regul. Comm'n*, 78 F.4th 827, 831 (5th Cir. 2023). *See also*, Nate Raymond, *US Supreme Court to Hear Nuclear Waste Storage Dispute*, REUTERS, Oct. 4, 2024.

[35] *Id.*

[36] 28 U.S.C. §§ 2342, 2344 (2023).

[37] *State ex rel. Balderas v. Nuclear Regul. Comm'n*, 59 F.4th 1112, 1116-1118 (10th Cir. 2023); *Don't Waste Mich. v. Nuclear Regul. Comm'n*, No. 21-1048, 2023 WL 395030, at *2-*3 (Jan. 25, 2023) (per curiam).

[38] The Tenth Circuit further determined that merely submitting comments on a draft environmental impact statement was insufficient to achieve such status. *Balderas v. NRC*, at 1123-1124.

[39] *Balderas v. NRC*, at 1123-1124 (citing *American Trucking Associations, Inc. v. I.C.C.*, 673 F.2d 82, 85 (5th Cir. 1982) (per curiam)).

[40] *Balderas v. NRC,* at 1123-1124

[41] In reaching that conclusion, the court acknowledged that four other courts of appeals "have refused to adopt" an ultra vires exception to the Hobbs Act's party-aggrieved requirement. *Texas v. Nuclear Regul. Comm'n*, 78 F.4th 827, 837 (5th Cir. 2023) (internal citations omitted).

[42] In reaching that conclusion, the court acknowledged that four other courts of appeals "have refused to adopt" an ultra vires exception to the Hobbs Act's party-aggrieved

Since both the Tenth and D.C. Circuits dismissed the case after determining that the petitioners did not qualify for "party aggrieved" status, these courts did not consider whether the NRC has the authority to license private, away-from-reactor CISFs.[43] In the Fifth Circuit, however, the case proceeded to the merits. The court determined that the NRC's authority to issue licenses was limited to the enumerated purposes in the Atomic Energy Act (AEA) and the Nuclear Waste Policy Act of 1982 (NWPA)—which do not include private storage or disposal.[44] Finding the AEA and NWPA to be unambiguous, the Fifth Circuit determined that, in the absence of a permanent repository, the statutes only authorize the NRC to license the storage of nuclear waste at federal facilities or onsite at civilian reactors and do not confer authority to the NRC to license private, away-from reactor CISFs.[45] Furthermore, the court held that even if the relevant statutory provisions are ambiguous, the Major Questions Doctrine would preclude any deference to the NRC's interpretation of those statutes because nuclear waste disposal "is of such economic and political importance that delegation to an agency must be clear" and "the applicable legislation provides no such clear delegation."[46]

The NRC and the Texas CISF applicant separately petitioned the Supreme Court for review in June 2024.[47] The Supreme Court agreed to hear the appeals in its new term starting in October 2024, with a decision expected at the end of June 2025.[48] The decision will clarify whether states and other interested groups must intervene in the NRC licensing process in order to have standing to petition for review under the Hobbs Act. Pending resolution of that issue, the Supreme Court's decision may determine whether private, offsite CISFs can be used to address the growing backlog of nuclear waste while the United States works towards a permanent solution.[49] This article focuses on the second issue on the merits before the Court. It begins with the historical and political context surrounding SNF waste management and a permanent storage solution in Part II. Part III provides more information about CISFs and the associated NRC licensing procedure. Part IV analyzes state laws and policies regarding the interim storage of SNF. Part V compares the NRC's and the Fifth Circuit's interpretations of the relevant statutory provisions that either authorize or deny the NRC's ability to license private, away-from-reactor CISFs. Lastly, Part VI concludes the article by discussing the potential impacts of a Supreme Court decision that limits the NRC's authority to authorize these types of interim storage facilities and the associated downstream effects on developing new nuclear power projects.

II. Nuclear Waste Management

Since the 1950s, nuclear power has comprised a significant portion of the electricity produced in the United States. Today it generates nearly 20% of the nation's total electricity and over 46% of the zero-carbon electricity produced in the U.S.[50] Waste from these facilities continues to accumulate at a rate of more than 2,000 tons annually.[51] According to CURIE, the DOE's resource portal for nuclear waste management information, as of December 2024, approximately 95,000 metric tons of SNF from operating and previously decommissioned facilities has accumulated.[52]

Countries that generate nuclear waste widely consider deep geological disposal as the safest and best

requirement. *Texas v. NRC*, 78 F.4th 827, 837 (5th Cir. 2023) (internal citations omitted).

[43] *State ex rel. Balderas v. Nuclear Regul. Comm'n*, 59 F.4th 1112, 1116-1118 (10th Cir. 2023); *Don't Waste Mich. v. Nuclear Regul. Comm'n*, No. 21-1048, 2023 WL 395030, at *2-*3 (Jan. 25, 2023) (per curiam); Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 3-4 (2024).

[44] Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 4 (2024).

[45] *Id.*

[46] *Id. (*citing *Texas v. NRC*, 78 F.4th at 844.)

[47] Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 4 (2024).

[48] Nate Raymond, *US Supreme Court to Hear Nuclear Waste Storage Dispute*, REUTERS, Oct. 4, 2024; Greg Stohr, *Nuclear Waste Storage Site in Texas Draws Supreme Court Review*, BLOOMBERG NEWS, Oct. 4, 2024.

[49] Greg Stohr, *Nuclear Waste Storage Site in Texas Draws Supreme Court Review*, BLOOMBERG NEWS, Oct. 4, 2024.

[50] U.S. DEP'T OF ENERGY, DOE/NE-0088, THE HISTORY OF NUCLEAR ENERGY 8-9 (1998); U.S. ENERGY INFO. ADMIN., *Frequently Asked Questions (FAQs): What is U.S. electricity generation by energy source?*, https://www.eia.gov/tools/faqs/faq.php?id=427&t=3 (last updated Feb. 29. 2024).

[51] U.S. GOV'T ACCOUNTABILITY OFF., GAO-21-603, COMMERCIAL SPENT NUCLEAR FUEL: CONGRESSIONAL ACTION NEEDED TO BREAK IMPASSE AND DEVELOP A PERMANENT DISPOSAL SOLUTION (2021).

[52] CURIE, Resource Portal for DOE Nuclear Waste Management Information, https://curie.pnnl.gov/map (last visited Dec. 17, 2024).

option for permanent disposal.[53] Siting such a facility, however, has been described by some U.S. officials as the "most intractable challenge for the U.S. nuclear waste management program."[54] Congress initially tried to address the siting challenge through legislation, but after decades without forward progress, the DOE has changed direction to pursue consent-based processes.

1. Yucca Mountain

The Nuclear Waste Policy Act of 1982 (NWPA) established the federal government's "responsibility to provide for the permanent disposal of high-level radioactive waste and… spent nuclear fuel."[55] It also directed the DOE to identify a suitable location for a permanent nuclear waste repository. From 1982 through 1987, the DOE studied nine sites to determine a technically viable site to permanently store and dispose of the nation's SNF.[56] In 1987, Congress amended the NWPA and directed the DOE to focus its efforts and studies solely on Yucca Mountain in Nevada, located approximately 90 miles from Las Vegas.[57] Congress narrowed the search for a permanent repository to Yucca Mountain for a multitude of reasons, some of which are disputed, including: the high costs of geologically characterizing multiple sites for permanent storage,[58] its location on federally owned land with preexisting contamination from nuclear weapons testing,[59] its promising geological and hydrological suitability,[60] and the lack of political power Nevada held in Congress.[61] The NWPA also gave the DOE the authority to enter into the contracts with private utilities and established the Nuclear Waste Fund to collect fees from commercial reactors to pay for developing a permanent repository, among other things.[62]

By 1997, Congress had directed the DOE to furnish a viability assessment of Yucca Mountain to itself and the President.[63] Thus, in 1998, the DOE delivered its assessment confirming Yucca Mountain's suitability for a permanent repository.[64] Subsequently in 2002, "after a decade of scientific study,"[65] then-President George W. Bush signed a resolution establishing the Yucca Mountain project as the nation's permanent repository.[66]

Ultimately, however, efforts to site a permanent repository at Yucca Mountain failed for social and political reasons. Lack of social license for the project among Nevada citizens created insurmountable impediments to the project.[67] Then-junior senator Harry Reid of Nevada raised fairness concerns over the 1987 amendments to the

[53] In fact, deep geological disposal is the preferred option for most countries who manage SNF, including: Argentina, Australia, Belgium, Canada, Czech Republic, Finland, France, Japan, the Netherlands, Republic of Korea, Russia, Spain, Sweden, Switzerland, and the UK. The Nuclear Fuel Cycle: Storage and Disposal of Radioactive Waste, WORLD NUCLEAR ASSOC., https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste#interim-waste-storage-and-transport (last updated Apr. 24, 2024).

[54] BLUE RIBBON COMMISSION ON AMERICA'S NUCLEAR FUTURE, REPORT TO THE SECRETARY OF ENERGY viii (Jan. 2012) [hereinafter BRC Report].

[55] 42 U.S.C. § 10131 (a)(4); Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100- 203, 101 Stat. 1330-227.

[56] Catherine Clifford, *Clean Energy: The feds have collected more than $44 billion for a permanent nuclear waste dump — here's why we still don't have one*, CNBC, Dec. 19, 2021; Mark Holt, CONG. RSCH. SERV., RL33461, CIVILIAN NUCLEAR WASTE DISPOSAL (2021).

[57] 42 U.S.C. § 10134 (2024); *Id*. at § 10172; Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100- 203, 101 Stat. 1330-227.

[58] John S. Stuckless & Robert A. Levich, *The Road to Yucca Mountain—Evolution of Nuclear Waste Disposal in the United States*, ENV'T & ENG'G GEOSCIENCE, Feb. 2016, at 1; Allison MacFarlane, *Underlying Yucca Mountain: The Interplay of Geology and Policy in Nuclear Waste Disposal*, 33 SOC. STUD. OF SCI. 783, 787 (2003).

[59] Allison MacFarlane, *Underlying Yucca Mountain: The Interplay of Geology and Policy in Nuclear Waste Disposal*, 33 SOC. STUD. OF SCI. 783, 787 (2003).

[60] *Id*. at 787-788.

[61] *Id*.

[62] Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 1 (2024); U.S. GOV'T ACCOUNTABILITY OFF., GAO-21-603, COMMERCIAL SPENT NUCLEAR FUEL: CONGRESSIONAL ACTION NEEDED TO BREAK IMPASSE AND DEVELOP A PERMANENT DISPOSAL SOLUTION 1 (2021).

[63] Energy and Water Development Appropriations Act, 1997, Pub. L. No. 104-206, 110 Stat. 2984 (1996).

[64] Approval of Yucca Mountain Site, Pub. L. No. 107-200, 116 Stat. 735 (2002).

[65] Press Release, Statement by Press Secretary, President Signs Yucca Mountain Bill (July 23, 2002), https://georgewbush-whitehouse.archives.gov/news/releases/2002/07/20020723-2.html.

[66] *Id*., H.R. Rep. No. 107-425, 107th Cong. (2002).

[67] *See The Fight Against Yucca Mountain*, Nevada Attorney General, https://ag.nv.gov/Hot_Topics/Issue/Yucca/ (last visited Dec. 16, 2024); *See* William Beaver, *The Demise of Yucca Mountain*, 14 THE INDEP. REV. 535, 540-41 (2010).

NWPA because senators from more powerful states spearheaded and facilitated Congress's focus on Yucca Mountain, without Nevada's consent, thereby forcing Nevada to be the only state under consideration for a permanent repository that clearly no other state wanted.[68] Nevadans also found it unfair that their state, not a state in the eastern U.S., would be burdened with permanently storing the nation's SNF when the bulk of the waste is located in the eastern U.S.[69] The state protested the Yucca Mountain repository in every way it could: it passed a state law prohibiting the storage of high-level radioactive waste within the state,[70] took various legal actions against the DOE, refused to issue the environmental permits the DOE would need to study the site, and submitted 229 technical objections to the NRC.[71] By the time DOE applied for a construction license in 2008, then-presidential candidate Barack Obama was campaigning against the project with then-senate majority leader Reid.[72] Subsequently in 2010, President Obama cut funding for Yucca Mountain from his 2010 budget.[73]

At this point, efforts to build a repository at Yucca Mountain have all but ceased. Not only would resuming construction at Yucca Mountain be politically and socially difficult due to lingering concerns about procedural fairness and radiation,[74] the DOE would need to obtain new spending authorization from Congress and resume its licensing efforts. Following the loss of funding, the DOE attempted to withdraw its application for the Yucca Mountain construction license.[75] The NRC, however, was divided over whether to allow the DOE to do so. Instead of making a decision, in 2011 the NRC suspended the licensing adjudication and preserved and documented the associated information it had gathered from the proceeding.[76]

The DOE has also stopped collective funds for the repository. In 2014, the U.S. Court of Appeals for the D.C. Circuit ruled that the DOE must set the Nuclear Waste Fund user fee to zero and stop collecting funds from owners and operators of nuclear power plants "until the federal government resumes licensing a geologic repository at Yucca Mountain or Congress enacts an alternative management plan to dispose of commercial spent nuclear fuel."[77] The DOE cannot access existing funds in the Nuclear Waste Fund to build a permanent repository unless Congress authorizes a new appropriation.[78] Therefore, efforts to develop a permanent repository at Yucca Mountain are currently paused and in limbo for the foreseeable future.[79]

2. Consent-Based Siting

Following the siting failures at Yucca Mountain, the DOE has shifted towards a "consent-based" approach to choosing a location or locations for a federal SNF management facility. In 2010, the Obama Administration created a bipartisan panel called the Blue-Ribbon Commission on America's Nuclear Future (BRC) "to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle and recommend a new strategy[.]"[80]

The BRC confirmed that deep geological disposal is the best permanent solution for SNF disposal.[81] However, to avoid repeating prior failures, the BRC recommended using a consent-based siting approach. According to the 2012 BRC report: "In practical terms, this means encouraging communities to volunteer to be considered to host a new nuclear waste management

---

[68] William Beaver, *The Demise of Yucca Mountain*, 14 THE INDEP. REV. 535, 540, 543 (2010).
[69] *Id*. at 543.
[70] NEV. REV. STAT. § 459.910 (2023).
[71] William Beaver, *The Demise of Yucca Mountain*, 14 THE INDEP. REV. 535, 541 (2010).
[72] More than 70% of Nevadans oppose the project and opposing the project has essentially become a prerequisite for Nevada politicians wishing to get elected to a state-wide or national office. William Beaver, *The Demise of Yucca Mountain*, 14 THE INDEP. REV. 535, 544 (2010); Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 2 (2024); Catherine Clifford, *Clean Energy: The feds have collected more than $44 billion for a permanent nuclear waste dump — here's why we still don't have one*, CNBC, Dec. 19, 2021; Mark Holt, CONG. RSCH. SERV., RL33461, CIVILIAN NUCLEAR WASTE DISPOSAL (2021).
[73] *Id*.
[74] William Beaver, *The Demise of Yucca Mountain*, 14 THE INDEP. REV. 535, 544 (2010).
[75] U.S. Dep't of Energy (High-Level Waste Repository), Docket No. 63-001-HLW, 74 N.R.C. 212 (2011).
[76] *Id*.
[77] U.S. GOV'T ACCOUNTABILITY OFF., GAO-21-603, COMMERCIAL SPENT NUCLEAR FUEL: CONGRESSIONAL ACTION NEEDED TO BREAK IMPASSE AND DEVELOP A PERMANENT DISPOSAL SOLUTION 18 (2021); *Nat'l Ass'n of Regul. Util. Comm'rs v. U.S. Dep't of Energy*, 736 F.3d 517 (D.C. Cir. 2013).
[78] Catherine Clifford, *Clean Energy: The feds have collected more than $44 billion for a permanent nuclear waste dump — here's why we still don't have one*, CNBC, Dec. 19, 2021.
[79] *Id*.
[80] BRC Report, *supra* note 54, at preamble.
[81] *Id*. at xi.

facility while also allowing for the waste management organization to approach communities that it believes can meet the siting requirements."[82] The BRC defined consent in this context as "the willingness of affected units of government – the host states, tribes, and local communities – to enter into legally binding agreements with the facility operator, where these agreements enable states, tribes, and communities to have confidence that they can protect the interests of their citizens."[83]

Today, DOE is implementing a consent-based siting program as part of its efforts to obtain a license for one or more federally-owned, away-from-reactor interim storage facility.[84]—Today, the DOE refers to its consent-based process as one which prioritizes the needs and concerns of the community proposed to host an SNF storage or disposal facility.[85] The DOE has broken its consent-based approach into three stages: 1) planning and capacity building in which the DOE seeks to build relationships in the community and develop a common understanding for nuclear waste management; 2) site screening and assessment whereby the DOE develops site-specific factors to consider when assessing a potential site for a CISF, including soliciting input from interested communities for additional factors that ensures hosting a CISF aligns with that communities goals and interests; 3) negotiating agreements with willing and informed communities before proceeding with licensing, construction, and operation of the CISF.[86]

These current efforts, however, will not definitively resolve the SNF problem. DOE's consent-based efforts are solely focused on identifying a suitable location for an interim storage facility: The need for a permanent storage solution will still remain. As of today, Yucca Mountain is the only option for a permanent repository under the amended NWPA.[87] Progress on permanent storage would either require Congress to appropriate funding for Yucca Mountain or to amend the NWPA again to allow for a permanent solution at an alternative location with greater local support.[88]

III. Longer-Term SNF Storage Solutions: CISFs

In response to the continued accumulation of SNF at reactor sites, the DOE and private parties have initiated CISF development projects to provide an "interim" solution for managing the nation's SNF.[89] Compared to a permanent storage facility that would involve deep underground excavation, a CISF would house dry casks from multiple reactor sites across the country together in one place above ground.[90] Additionally, since CISFs

---

[82] *Id.*

[83] *Id.*

[84] Please note that there are different citing procedures for federally owned CISFs and privately owned CISFs. Additionally, the DOE is prohibited from constructing a federally-owned interim storage facility until it obtains a license for a permanent repository, which will be further in Part III. U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, *U.S. Department of Energy Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*, https://www.energy.gov/ne/us-department-energy-consent-based-siting-process-federal-consolidated-interim-storage-spent (updated 2023).

[85] U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, *Consent-Based Siting*, https://www.energy.gov/ne/consent-based-siting (last visited Dec. 16, 2024).

[86] U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, *U.S. Department of Energy Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*, https://www.energy.gov/ne/us-department-energy-consent-based-siting-process-federal-consolidated-interim-storage-spent (updated 2023); U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, CONSENT-BASED SITING PROCESS FOR FEDERAL CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL 12 (Apr. 2023); U.S. DEP'T OF ENERGY, DRAFT CONSENT-BASED SITING PROCESS FOR FEDERAL CONSOLIDATED INTERIM STORAGE AND DISPOSAL FACILITIES FOR SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE 16-18 (Jan. 2017).

[87] Catherine Clifford, *Clean Energy: The feds have collected more than $44 billion for a permanent nuclear waste dump — here's why we still don't have one*, CNBC, Dec. 19, 2021; Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100- 203, 101 Stat. 1330-227.

[88] Catherine Clifford, *Clean Energy: The feds have collected more than $44 billion for a permanent nuclear waste dump — here's why we still don't have one*, CNBC, Dec. 19, 2021; Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 2 (2024).

[89] U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, *Department of Energy Moves Forward with Consolidated Interim Storage Facility Project for Spent Nuclear Fuel,* https://www.energy.gov/ne/articles/department-energy-moves-forward-consolidated-interim-storage-facility-project-spent (last updated May 15, 2023); Consolidated Interim Storage Facility (CISF), U.S. NUCLEAR REGUL. COMM'N, https://www.nrc.gov/waste/spent-fuel-storage/cis.html (last updated Dec. 8, 2020); Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 2 (2024).

[90] Catherine Clifford, *Clean Energy: The feds have collected more than $44 billion for a permanent nuclear*

provide the means to consolidate and centralize exiting SNF,[91] adding CISFs to the U.S.'s nuclear waste management portfolio could provide a way for the federal government to take tangible steps towards solving the SNF backlog.[92]

CISFs can be operated by either private commercial enterprises or by the federal government through the DOE.[93] Currently, however, under the amended NWPA, the DOE is required to obtain a license from the NRC for a permanent repository *before* beginning construction on its own CISF.[94] Accordingly, as of today, only private facilities can be licensed.

NRC Licensing Processes for CISFs

The NRC's jurisdiction encompasses nuclear safety concerns, making the NRC responsible for performing a technical review of all safety and environmental protection aspects of a proposed CISF.[95] The Atomic Energy Act (AEA) authorizes the NRC to issue licenses for the possession or transference of special nuclear material, source material, and byproduct material.[96] SNF consists of all three types of material.[97] Thus, the NRC licenses the possession of SNF by issuing a materials license covering all three constituent materials.[98] After the AEA was passed, the NRC promulgated 10 C.F.R. Part 72 to establish "a formal process for licensing temporary storage of spent fuel."[99] While onsite storage of waste generated at the facility is considered part of a nuclear facility's general license, CISFs require a specific license from the NRC.[100]

The thrust of the licensing procedures requires the NRC to conduct a safety review during which the NRC determines if the application demonstrates that the CISF's design meets the applicable safety regulations.[101] All applicants, including the DOE, for CISF licenses are required to prove that the proposed facility adheres to the NRC's safety requirements.[102] The Part 72 regulations authorize the NRC to engage with applicants in an iterative process until the applicant's "design meets the requirement in 10 C.F.R. Part 72, or until the review is closed by the NRC or the applicant."[103] If applicable, at the conclusion of its safety review, the NRC prepares a safety evaluation report (SER) that "describes the basis for the NRC's approval and issuance of a specific license" for the CISF as well as any recommended license conditions and technical

---

waste dump — here's why we still don't have one, CNBC, Dec. 19, 2021.

[91] U.S. DEP'T OF ENERGY, NL/RPT-21-64973, SPENT FUEL AND WASTE DISPOSITION: SUMMARY OF CONSOLIDATED INTERIM STORAGE ADVANTAGES AND DISADVANTAGES FROM AN INTEGRATED SYSTEMS PERSPECTIVE FROM PRIOR REPORTS AND STUDIES iii (2023); U.S. NUCLEAR REGUL. COMM'N, NUREG-2237, ENVIRONMENTAL IMPACT STATEMENT FOR THE HOLTEC INTERNATIONAL'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN LEA COUNTY, NEW MEXICO (2022); U.S. NUCLEAR REGUL. COMM'N, NUREG-2239, ENVIRONMENTAL IMPACT STATEMENT FOR INTERIM STORAGE PARTNERS LLC'S LICENSE APPLICATION FOR A CONSOLIDATED INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL IN ANDREWS COUNTY, TEXAS (2021).

[92] U.S. DEP'T OF ENERGY, NL/RPT-21-64973, SPENT FUEL AND WASTE DISPOSITION: SUMMARY OF CONSOLIDATED INTERIM STORAGE ADVANTAGES AND DISADVANTAGES FROM AN INTEGRATED SYSTEMS PERSPECTIVE FROM PRIOR REPORTS AND STUDIES 7 (2023) (explaining that a "[C]ISF may be the most expeditious and most certain way for the federal government to begin meeting its ethical, statutory, and contractual obligations to accept SNF for ultimate disposal.").

[93] *See* 10 C.F.R. § 72.1 (2024).

[94] 42 U.S.C. § 10168(d)(1) (2024)**;** Jason O. Heflin, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 2 (2024).

[95] *See Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1242-43 (10th Cir. 2004); Consolidated Interim Storage Facility (CISF), U.S. NUCLEAR REGUL. COMM'N, https://www.nrc.gov/waste/spent-fuel-storage/cis.html (last updated Dec. 8, 2020).

[96] *See* 42 U.S.C. § 2073; *see id*. § 2093; *see id*. § 2111. *See also* 42 U.S.C. §§ 2014(aa), (z), (e) (defining each term, respectively).

[97] Petition for Writ of Certiorari at 22, *U.S. Nuclear Regul. Comm'n v. Texas, et al.*, Nos. 23-1300 & 23-1312 (U.S. June 12, 2024) [hereinafter NRC Petition for Writ of Cert.].

[98] *See* 42 U.S.C. §2201(h) (2023).

[99] NRC Petition for Writ of Cert., *supra* note 97, at 22; *see also* 10 C.F.R.§ 72.1. (2023).

[100] A general license authorizes SNF storage at power reactor sites to those who are already authorized to "possess or operate a power reactor under 10 CFR Part 50 or 10 CFR Part 52"; while a specific license can be for SNF storage co-located with or remotely located from a reactor under 10 C.F.R. 72.3. U.S. NUCLEAR REGUL. COMM'N, NUREG-2215, FINAL REPORT: STANDARD REVIEW PLAN FOR SPENT FUEL DRY STORAGE SYSTEMS AND FACILITIES xxxvi (2020).

[101] *Id*. at xxxviii.

[102] *See* 10 C.F.R. § 72.22(d) (2023).

[103] U.S. NUCLEAR REGUL. COMM'N, NUREG-2215, FINAL REPORT: STANDARD REVIEW PLAN FOR SPENT FUEL DRY STORAGE SYSTEMS AND FACILITIES xxxviii (2020).

specifications and the respective bases therefor.[104] If no adjudicatory hearing is requested or granted, the review is complete when the NRC issues the SER and the license.[105] Otherwise, the subject matter and outcome of the particular hearing determines if and when the license is issued.[106]

The NRC is also required to conduct an environmental review pursuant to the National Environmental Policy Act (NEPA) before issuing a license for a CISF.[107] This can occur simultaneously with the safety review.[108] The requirements for NRC environmental reviews are set forth at 10 C.F.R. Part 51. The EIS process commences when the NRC first publishes a "notice of intent" in the Federal Register.[109] Next, the NRC conducts scoping to, *inter alia*, "define the proposed action," invite relevant members of the public to participate in the process, determine which state and local governments will be affected by the proposed CISF, and identify key environmental issues to address in the EIS.[110] The NRC then develops and publishes a draft EIS that lays out the environmental impacts of the licensing decision and the environmental impacts of any alternatives.[111] In the final EIS, the NRC must publish the substantive comments it receives[112] along with "any relevant responsible opposing view not adequately discussed" in the draft EIS,[113] meaningfully respond to the public comments on the draft EIS,[114] and issue a record of decision listing its preferred action.[115] Publishing the final EIS concludes the environmental review.

Additional requirements apply if the CISF will be owned and operated by the DOE. While the DOE is permitted to "design and seek a license for an interim storage facility," [116] it may not proceed with construction or operation of a federally-owned CISF, also known as 'monitored retrievable storage', without congressional authorization.[117] The activities the DOE can pursue without congressional authorization include "proceed[ing] with a consent-based siting process, negotiat[ing] an agreement with a host community, and design[ing] and seek[ing] a license for an interim storage facility."[118] Accordingly, the DOE's application must also specify "the provisions of the public law authorizing the construction and operation" of the CISF.[119] If the applicant is the DOE, the NRC will "send a copy of the notice of docketing to the Governor and legislature of any State" in which the proposed CISF may be located and "to the Chief Executive of the local municipality, to the Governors of any contiguous States and to the governing body of any affected Indian Tribe[.]"[120]

IV. State Laws and Policies on Interim Storage

Supremacy Clause Considerations

While the supremacy clause prohibits states from passing laws regarding nuclear safety, state legislatures can regulate or prohibit the construction of nuclear facilities for

---

[104] *Id*. at xxxviii.
[105] *Id.*
[106] *Id.*
[107] *See* 10 C.F.R. § 51.1(2024); *Winter v. Nat. Res. Def. Council, Inc.*, 555 U.S. 7, 23 (2008) (quoting *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 350 (1989)) ("NEPA imposes only procedural requirements to 'ensur[e] that the agency, in reaching its decision, will have available, and will carefully consider, detailed information concerning significant environmental impacts.'").
[108] *See* Interim Storage Partner's Waste Control Specialists Consolidated Interim Storage Facility, 83 Fed. Reg. 44070, 44070-71 (Aug. 29, 2018).
[109] *See* 10 C.F.R. § 51.116 (2024).
[110] 10 C.F.R. § 51.29(a) (2024); 10 C.F.R. § 51.28(a), (b) (2024); 40 C.F.R. § 1501.9(a), (b) (2024).
[111] *See* 10 C.F.R. § 51.71 (2024); 10 C.F.R. § 51.74 (2024).
[112] 10 C.F.R. § 51.91(a)(2) (2024).
[113] 10 C.F.R. § 51.91(b) (2024).
[114] 10 C.F.R. § 51.91(a)(1) (2024) ("The final environmental impact statement will include responses to any comments on the draft environmental impact statement or on any supplement to the draft environmental impact statement…[, including]: (i) Modification of alternatives, including the proposed action;" (ii) Development and evaluation of alternatives not previously given serious consideration; (iii) Supplementation or modification of analyses; (iv) Factual corrections; (v) Explanation of why comments do not warrant further response, citing sources, authorities or reasons which support this conclusion.")
[115] 10 C.F.R. § 51.91 (2024) ("The final environmental impact statement will include responses to any comments on the draft environmental impact statement or on any supplement to the draft environmental impact statement." (; 10 C.F.R. § 51.94 (2024).
[116] U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, *U.S. Department of Energy Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*, at 9 (updated 2023), https://www.energy.gov/ne/us-department-energy-consent-based-siting-process-federal-consolidated-interim-storage-spent.
[117] *Id*. Please note for consistency, "CISF" will be used instead of MRS for "monitored retrievable storage installation" as defined in the NWPA.
[118] *Id*.
[119] 10 C.F.R. § 72.22(d)(5)(ii).
[120] 10 C.F.R. § 72.16(e) (2024).

non-safety motivated reasons.[121] Based on the text of the AEA, the Supreme Court has determined that the federal government's interest in "the radiological safety aspects involved in the construction and operation of a nuclear plant" dominates over state interests in this highly technical field.[122] The Tenth Circuit in its 2004 *Skull Valley Band of Goshute Indians* opinion synthesized this preemption rule as:

> state laws within the entire field of nuclear safety concerns are preempted, even if they do not directly conflict with federal law. Thus, a state moratorium grounded in safety concerns falls squarely within the prohibited field, as would a state judgment that nuclear power is not safe enough to be further developed. However, if state regulation is grounded in 'a non-safety rationale,' it may fall outside the preempted field. [123]

The Supreme Court's 1983 opinion in *Pacific Gas & Electric Co.,* provides an example of a non-safety rationale for a state law that was not preempted by federal law.[124] In this case, the Court upheld a California statute imposing a moratorium on constructing new nuclear power plants within the state until the federal government provided a plan for nuclear waste disposal.[125] The Court found that California's concerns over the economic costs of constructing new nuclear powerplants without the necessary permanent storage facilities provided an adequate non-safety rationale and therefore, the statute fell outside the preempted field.[126] Furthermore, the Court determined that since Congress "had left to the states to determine whether, as a matter of economics, a nuclear power plant should be constructed[,]" California's "moratorium did not conflict with the objectives of federal law."[127]

The Tenth Circuit's *Skull Valley* provides a contrary example where state law was preempted. In *Skull Valley*, the court overturned a series of Utah laws related to SNF facilities which required county governments to impose regulations and restrictions on SNF storage, required a license from the state department of environmental quality, and established specific requirements related to use roads and railroad crossings for the transportation of SNF.[128] The court found that each of these laws were primarily intended to address radiological concerns and were therefore preempted by federal law. [129] For example, county planning provisions of the law required counties to either to prohibit storage of SNF or to adopt comprehensive land use plans addressing radiological safety issues to, among other purposes, mitigate the effects of SNF storage and guarantee "health and safety." [130] The court invalidated the road provisions of the statute based on a statement in the record made by Utah's governor that the laws in question "will add substantially to our ability as a state to protect the health and safety of our citizens against the storage of high-level nuclear waste."[131] The court then concluded "[t]he record thus establishes that the [Utah laws] were enacted for reasons of radiological safety and are therefore preempted" because "[a] state moratorium on nuclear construction grounded in safety concerns falls squarely within the prohibited field."[132] Even though regulation of land use and roads are typically the province of the state, *Skull Valley* illustrates that even if a state law purports to be grounded on preventing interim storage (or other nuclear developments) within the state, the state law could be

---

[121] *See Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1242 (10th Cir. 2004) (discussing three Supreme Court decisions that addressed the preemptive effect of the extensive federal regulatory scheme for nuclear power and safety concerns).

[122] *Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission,* 461 U.S. 190, 204-05 (1983).

[123] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1242 (10th Cir. 2004) (internal citations and quotations omitted).

[124] *Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission,* 461 U.S. 190, 216 (1983).

[125] *Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission,* 461 U.S. 190, 204-05 (1983).

[126] *Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission,* 461 U.S. 190, 216 (1983).

[127] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1243 (10th Cir. 2004) (citing *Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission,* 461 U.S. 190, 222 (1983)).

[128] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252 (10th Cir. 2004) (internal citations omitted).

[129] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252 (10th Cir. 2004) (internal citations omitted).

[130] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252 (10th Cir. 2004) (internal citations omitted).

[131] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252 (10th Cir. 2004) (internal citations omitted).

[132] *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252-53 (10th Cir. 2004) (citing *Pacific Gas*, 461 U.S. at 213).

subject to preemption if the record shows the reasons motivating the ban are based on safety concerns.[133]

A. State Level Interim Storage Law Developments

Several states have enacted laws related to the siting of interim storage facilities. These laws may ban storage, condition storage on the construction of a permanent repository, or which create state-level siting processes.

The 2021 law Texas passed in response to the NRC's decision to license the private Texas CISF provides an example of a state law that prohibits storage of high-level radioactive waste in the state.[134] This law, known as H.B. 7, allows storage only "at the site of currently or formerly operating nuclear power reactors and currently or formerly operating nuclear research and test reactors."[135] While facially the law appears to be intended to prevent interim storage, based on the precedent established in *Skull Valley*, H.B. 7 may be vulnerable to preemption challenges because of the motivation behind the law.[136] The legislative intent for H.B.7 is just that: "to ban the storage and disposal of high-level radioactive waste," including SNF, "in the State of Texas" and to "send a message to the Nuclear Regulatory Commission that the State of Texas does not consent to the storage or disposal of that type of waste."[137] However, Texas Governor Abbott also wrote a letter to the NRC concerning the private Texas CISF, stating it would pose "a greater radiological risk than Texas is prepared to allow."[138]

H.B. 7 may have broader implications for nuclear energy development in the state. H.B. 7's prohibition on storing any high-level waste within Texas (subject to the enumerated exceptions) could encompass both CISFs and further nuclear energy developments by default.[139] Since all nuclear reactors generate SNF as part of their operations, no new facilities could be licensed without the ability to store high level radioactive waste on site. However, H.B. 7's exceptions for onsite storage at currently operating reactors may allow for new nuclear research and power facilities if "currently" is interpreted to not preclude reactors developed after the law was passed in 2021.

While falling short of a moratorium, several state laws that condition interim storage within the state on the development of a federal, permanent repository.[140] For example, a New Mexico law prohibits storing SNF unless the state "has consented to or concurred in the creation of the disposal facility" and a federal permanent repository is in operation.[141] Conditioning interim storage on the

---

133 *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252 (10th Cir. 2004) (citing *English v. Gen. Elec. Co.,* 496 U.S. 72, 84-85 (1990) ("the Court [in *Pacific Gas*] defined the pre-empted field, *in part by reference to the motivation behind the state law,*" and in part by whether the law has "some direct and substantial effect on the decisions made by those who build or operate nuclear facilities") (emphasis added by the *Skull Valley* court)).

134 Erin Douglas, *Texas bans storage of highly radioactive waste, but a West Texas facility may get a license from the feds anyway*, TEX. TRIB., Sept. 30, 2021.

135 TEX. HEALTH & SAFETY CODE ANN. § 401.072 (West 2024).

136 *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1252 (10th Cir. 2004) (citing *English v. Gen. Elec. Co.,* 496 U.S. 72, 84-85 (1990) ("the Court [in *Pacific Gas*] defined the pre-empted field, *in part by reference to the motivation behind the state law,*" and in part by whether the law has "some direct and substantial effect on the decisions made by those who build or operate nuclear facilities") (emphasis added by the *Skull Valley* court)).

137 TEXAS HOUSE JOURNAL, 87TH LEGISLATURE – SECOND CALL SESSION, at 379-380, https://journals.house.texas.gov/hjrnl/872/pdf/87C2DAY07CFINAL.PDF#page=19.

138 Erin Douglas, *Texas bans storage of highly radioactive waste, but a West Texas facility may get a license from the feds anyway*, TEX. TRIB., Sept. 30, 2021.

139 In fact, according to legislative discussions about the intent of H.B. 7, Texas Representative Landgraf in addressing a question posed by Representative Goodwin stated: "This bill, as we talked about, is very specific to banning the storage and disposal of high-level radioactive waste, including spent nuclear fuel. You have brought up the [private CISF] application [under consideration by the NRC] several times. There's certainly—if the license is issued by the NRC, which we expect as early as September 13, this bill, particularly if it's enacted and takes immediate effect, would address parts of the license that is being applied for. But that license is independent of this bill itself. This bill is designed to cover multiple situations, not to apply to a single license, although it would have some applicability there." TEXAS HOUSE JOURNAL, 87TH LEGISLATURE – SECOND CALL SESSION, at 381, https://journals.house.texas.gov/hjrnl/872/pdf/87C2DAY07CFINAL.PDF#page=19.

140 *See, e.g.,* N.M. Stat. Ann. § 74-4A-11.1; Cal. Pub. Res. Code § 25524.1; Utah Code Ann. § 19-3-301; Wyo. Stat. Ann. § 35-11-1506.

141 N.M. Stat. Ann. § 74-4A-11.1.

presence of a permanent repository could have the same practical effect as the complete ban on developing interim storge in Texas's H.B. 7. Due to the lack of permanent repository and the inextricable link between nuclear energy production and interim storage for the resulting waste, such conditions could create a de facto moratorium on all new nuclear energy developments in the state.

Contrary to the position Texas has taken, Wyoming has recently enacted and proposed legislation that to remove barriers to both onsite and consolidated storage.[142] The state legislature has promulgated these laws in conjunction with the development of a commercial advanced small modular reactor (SMR) project sited in Kemmerer, Wyoming, the first such project to begin construction in the U.S.[143] In 2022, the Wyoming legislature passed Wyoming Statute § 35-11-1506, which explicitly allows the interim storage of SNF onsite at nuclear power plants within the state.[144] Like New Mexico, currently, § 35-11-1506 and other provisions of Wyoming law prohibit interim storage facilities located offsite from reactors until the federal government establishes a permanent repository along with storing nuclear waste produced from out of state.[145]

However, in October 2024, the Joint Minerals, Business and Economic Development Committee, a Wyoming legislative panel, approved a draft bill to amend § 35-11-1506 and plans to sponsor and present the bill in front of the full legislature in January 2025.[146] The amendments, if passed, would remove the requirement for a national repository, resolve conflicts between Wyoming law and NRC regulations, and better position Wyoming to consider providing interim storage for nuclear waste generated outside the state.[147] Proponents of the bill have emphasized that the amendments do not actually propose or authorize any specific storage facilities, but that they only remove existing legislative barriers should the state decide to pursue such action in the future.[148] Proponents also highlight the economic incentives of nuclear waste storage, especially considering private enterprises would bear the costs of initial investments for a facility and that the state is already providing interim storage as part of the SMR project.[149] Yet, even if the proposed law is passed, whether private facilities could develop a CISF in the state may turn on the Supreme Court's decision in *Texas v. NRC.*

V. The Supreme Court Litigation

The Supreme Court's review of the Texas CISF license presents two issues on appeal: 1) Whether Texas and the other respondents are eligible to obtain judicial review of the NRC's decision to license the Texas CISF; and 2) Whether the NRC has the authority to issue licenses for away-from-reactor, private CISFs based on the text of the AEA and NWPA.[150] While a discussion of the first issue is beyond the scope of this article, the Court may not reach the merits of the second issue if it decides the respondents are ineligible to obtain judicial review of the NRC's licensing decision. Should the Court reach the merits, however, its decision will have broad implications for the viability of CISFs as a longer-term storage strategy.

The NRC's authority to license private, away-from-reactor CISFs

If the Court reaches the merits, it will need to determine whether the AEA and NWPA grant the NRC authority to license private, away-from-reactor CISFs. First, the Court will need to determine whether or not the statutes are ambiguous. If the Court finds the statutes unambiguous, it will need to determine whether the NRC's or Fifth Circuit's reading of those statutes is correct or provide its own reading of those statutes. If the Court finds these statutes ambiguous, the Court will have to sift through a labyrinth of difficult-to-reconcile statutory interpretation doctrines to determine the bounds of the

142 *See* Nuclear Power Generation and Storage Amendments, HB0131, 66th Leg. (2022), codified at Wyo. Stat. Ann. §35-11-1506(e)(1) (2023); *See* Joint Minerals, Business & Economic Development Committee, October 8, 2024-PM at 1:50 – 1:56.

143 Sonal Patel, *Kemmerer 1 Breaks Ground: A Look at TerraPower's Natrium Fast Reactor Nuclear Power Plant*, POWER (June 13, 2024).

144 Nuclear Power Generation and Storage Amendments, HB0131, 66th Leg. (2022), codified at Wyo. Stat. Ann. §35-11-1506(e)(1) (2023).

145 *See* Wyo. Stat. Ann. §35-11-1506(a), (e)(1) (2023); *See* Wyo. Stat. Ann. §35-11-1504(b) (conditioning certain steps of Wyoming's licensing process for siting interim storage facilities on a federal permanent repository)

146 Wyo. Legislature, *Joint Minerals, Business & Economic Development Committee October 8, 2024-PM*, YOUTUBE (Oct. 8, 2024) at 1:50 – 1:56, https://www.youtube.com/watch?v=ow_4TLbdqTE&list=PLOhkcX5d91Nq2tJM71LM3HkMqIy2NDDfg.

147 Joint Minerals, Business & Economic Development Committee, October 8, 2024-PM at 1:50 – 1:56;

148 *See* Joint Minerals, Business & Economic Development Committee, October 8, 2024-PM at 1:50 – 1:58

149 *See* Joint Minerals, Business & Economic Development Committee, October 8, 2024-PM at 1:50 – 1:56;

150 Brief for the Federal Petitioners at (I), *Nuclear Regul. Comm'n. et al*., v. *Texas*, Nos. 23-1300 & 23-1312 (U.S. Dec. 2, 2024).

NRC's authority to license private, away-from-reactor CISFs.

Contradictory Interpretations over the AEA's and NWPA's Plain Text

The NRC's position is that the AEA's unambiguous plain text authorizes the Commission to license offsite storage of SNF and that its authority is not limited by the NWPA.[151] This position is supported by a 2004 D.C. Circuit Court opinion – *Bullcreek v. Nuclear Regulatory Commission* – later followed by the Tenth Circuit.[152] The AEA grants the Commission the authority to license the possession of ''special nuclear material,''[153] ''source material,''[154] and ''byproduct material[.]''[155] According to the NRC and *Bullcreek*, because SNF consists of all three types of material, these provisions authorize the NRC to grant a materials license covering all three to "a private party that wishes to possess spent fuel."[156] This position is reinforced by the NRC's "longstanding regulatory practice," which, since promulgation of Part 72 in 1980, has included "a formal process for licensing temporary storage of spent fuel, both at and away from nuclear reactors."[157] When promulgating the Part 72 regulations, the NRC emphasized that the regulations only established requirements for "temporary storage" which it defined as "interim storage of spent fuel for a limited time only, pending its ultimate disposal."[158]

In *Texas v. NRC*, however, the Fifth Circuit disagreed with this interpretation. It determined that in the absence of a federal repository, the AEA limits the NRC's authority to license SNF waste storage except at federally-owned facilities or onsite at civilian reactors.[159] The court reasoned that since the AEA does not specifically refer to SNF, nor licensing its constituent materials for the purposes of offsite storage and disposal, the Act did not authorize the NRC to license the Texas CISF. [160] The Fifth Circuit also determined that, according to the NWPA, "until there's a permanent repository, spent nuclear fuel is to be stored onsite at-the-reactor or in a federal facility,"[161] thus leaving no authority to grant a license to a facility that is both private and offsite. The Fifth Circuit characterized the NWPA as the legislation that established and governs the measures the NRC can use to "deal with" SNF.[162]

In its briefing to the Supreme Court, the NRC counters that its "separate licensing authority for facilities reinforces the agency's materials-licensing authority."[163] The NRC explains that because "nuclear power plants cannot operate without creating"[164] SNF, the NRC's licensing scheme for nuclear power plants requires operators to obtain two licenses – (1) a facilities license for the equipment and devices capable of producing or making use of "special nuclear material", and (2) a materials license to possess nuclear fuel and SNF.[165] In contrast, the NRC only requires a materials license for facilities "that are essential to the generation of nuclear power" but do not produce or make use of special nuclear materials.[166] A CISF operator, which only stores SNF, would fall into this latter category and would only require a materials license. The NRC argues that its "authority to license the possession of materials at such facilities confirms that the Commission's materials-licensing authority sweeps well beyond the licensing of nuclear power plants" and permits it to license possession of materials for both onsite and offsite storage of spent fuel.[167] The NRC further argues that issuing facilities licenses at nuclear power plants "would serve no practical purpose unless [it could] also license the storage of spent fuel *somewhere*[.]"[168] It contends the AEA must confer the ability to license SNF based on the three constituent materials listed in the Act, because otherwise it

[151] *Id*. at 31, 42-43.
[152] *Bullcreek v. NRC*, 359 F.3d 536, 360 U.S. App. D.C. 184 (D.C. Cir. 2004); *Skull Valley Band of Goshute Indians v. Nielson*, 376 F.3d 1223, 1232 (2004), cert. denied, 546 U.S. 1060 (2005)
[153] *See* 42 U.S.C. § 2073;
[154] *See id*. § 2093
[155] *See id*. § 2111. See also 42 U.S.C. §§ 2014(aa), (z), (e) (defining each term, respectively).
[156] NRC Petition for Writ of Cert., *supra* note 97, at 20.
[157] *Id*. at 22.
[158] Brief for the Federal Petitioners at 22, *Nuclear Regul. Comm'n. et al*., v. *Texas*, Nos. 23-1300 & 23-1312 (U.S. Dec. 2, 2024) (citing 45 Fed. Reg. at 74,694).
[159] JASON O. HEFLIN, CONG. RSCH. SERV., LSB11199, CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL: RECENT LICENSING DECISIONS 4 (2024).
[160] *State of Texas v. Nuclear Regulatory Commission*, 78 F.4th 827, 840-41 (5th Cir. 2023).
[161] *State of Texas v. Nuclear Regulatory Commission*, 78 F.4th 827, 844 (5th Cir. 2023).
[162] *See State of Texas v. Nuclear Regulatory Commission*, 78 F.4th 827, 843 (5th Cir. 2023).
[163] Brief for the Federal Petitioners at 36, *Nuclear Regul. Comm'n. et al*. v. *Texas*, Nos. 23-1300 & 23-1312 (U.S. Dec. 2, 2024).
[164] *Id*. at 39.
[165] *Id*. at 36-37.
[166] An example of such facility is a fuel fabrication facility that "converts enriched uranium in into fuel for nuclear reactors," but "is *not* a production or utilization facility under the Act[.]" *Id*. at 37. (emphasis added in the original).
[167] *Id*.
[168] *Id*. at 39.

could not license onsite storage—a power neither party disputes.[169]

The NRC also disagrees with the Fifth Circuit's determination that the NWPA provisions "are *themselves* the source of the Commission's authority to license private *onsite* storage of spent nuclear fuel[,]" and that the NWPA's lack of affirmative language authorizing offsite storage thus prohibits offsite storage.[170] According to the NRC, the NWPA did not vest it "with *new* authority to license private onsite storage; they instead reflected Congress's understanding that such storage was already permissible."[171] The NRC argues the NWPA "neither limited, repealed, nor expanded the Commission's authority under the Atomic Energy Act to license private storage of spent nuclear fuel. Rather, the [NWPA] addressed separate issues" including a federal interim storage program (that was never implemented) and the construction of a permanent repository.[172] Furthermore, the NRC argues that since Congress passed the NWPA two years after the NRC promulgated the Part 72 regulations that expressly authorize licensing offsite interim storage of SNF, "'Congress was aware' that the Commission had interpreted the Atomic Energy Act to authorize the licensing of offsite and onsite storage of spent fuel, the [NWPA] 'left untouched' that preexisting authority."[173] Based on that legislative history, the NRC's brief concluded that "absent any specific [NWPA] provision that could reasonably be construed to prohibit offsite storage of spent fuel—and the court identified none—the [Fifth Circuit's] sense of general congressional policy provided no sound basis for reading such a prohibition into the Act."[174]

1. Contradictory Doctrines for Resolving Ambiguities in the AEA and NWPA

Should the Court find the AEA and NWPA ambiguous, the likelihood of the Supreme Court deferring to the NRC in this case presents an interesting, yet puzzling overarching question. In light of precedent and recent decisions regarding agency deference, it is more unclear than ever how much weight the Court will give to the NRC's interpretation of the relevant statutory provisions.

The NRC is largely understood to be afforded "super deference" by courts due to the NRC's status as an independent agency overseeing highly technical operations within its specialty.[175] A 1991 D.C. Circuit Court opinion characterized the judiciary's role as awarding the NRC "heightened deference for NRC licensing decisions that flows from its broad statutory mandate [under the AEA]."[176] Thus, the Fifth Circuit's invocation of the Major Questions Doctrine (MQD) is surprising support for its decision to withhold deference to the NRC's interpretation of the relevant AEA and NWPA provisions, in the event those provisions are found ambiguous.[177] The MQD came out of the 2022 Supreme Court case *West Virginia v. EPA*, which, in short, held that a unless Congress "speak[s] clearly," courts should not defer to an agency's interpretation of a statute in on matters of "vast economic and political significance."[178] The MQD does not appear on its face to apply to the NRC because the MQD is widely regarded as a carveout from *Chevron* deference, the deference (formerly) owed to certain agency interpretations of statutory ambiguities.[179] Accordingly, as the NRC has traditionally not been subject to the limits of

---

[169] *Id*.
[170] *Id*. at 46.
[171] *Id*.
[172] *Id*. at 42-44 (citing 42 U.S.C. 10151- 10157; 42 U.S.C. 10131-10145).
[173] *Id*. at 44 (citing *Bullcreek v. Nuclear Regulatory Comm'n*, 359 F.3d 536, 542 (D.C. Cir. 2004).
[174] *Id*. at 46.
[175] *See, e.g., Massachusetts v. NRC* 924 F.2d 311, 324 (D.C. Cir. 1991) (internal citations omitted); *Siegel v. Atomic Energy Comm'n*, 400 F.2d 778, 783 U.S. App. D.C. 307 (D.C. Cir. 1968) (explaining how the AEA's statutory scheme was "virtually unique in the degree to which broad responsibility is reposed in the administering agency, free of close prescription in its charter as to how it shall proceed in achieving the statutory objectives.")
[176] *Massachusetts v. NRC* 924 F.2d 311, 324 (D.C. Cir. 1991) ("Our standard of review on this question is necessarily deferential. We will not overturn the Commission's interpretation of its own [] rule unless that interpretation is plainly inconsistent with the language of the regulation[]. If [the NRC's] reading of [its regulation] satisfies that standard, the Commission's application of the regulation … may be set aside only if it was arbitrary, capricious, an abuse of discretion, or otherwise contrary to law. Moreover, *the Commission's licensing decisions are generally entitled to the highest judicial deference because of the unusually broad authority that Congress delegated to the agency under the Atomic Energy Act*.") (emphasis added).
[177] *Texas v. Nuclear Regul. Comm'n*, 78 F.4th 827, 844 (5th Cir. 2023).
[178] *West Virginia v. EPA*, 597 U.S. 697, 716, 721 (2022) ("our precedent teaches that there are 'extraordinary cases' that call for a different approach—cases in which the 'history and the breadth of the authority that [the agency] has asserted,' and the 'economic and political significance' of that assertion, provide a 'reason to hesitate before concluding that Congress' meant to confer such authority.") (internal citations and quotations omitted.)
[179] *Chevron* (which was recently overturned) deference comes from a 1984 case and provides the notion that courts

Chevron deference,[180] it logically follows it would not be subject to *Chevron*'s more restrictive MQD carveout, either.

Further complicating this analysis, since the Fifth Circuit ruled on the merits in the Texas CISF case, the Supreme Court has overturned *Chevron* and in its stead issued *Loper Bright* in June 2024.[181] Again, with the MQD's link to *Chevron*, it is not clear if and how the MQD applies in this case or any case moving forward under *Loper Bright,*[182] or if the MQD is a standalone doctrine that can apply to any agency action.[183] Should the Supreme Court reach the merits on the Texas CISF case, the Court may need to reconcile the MQD with *Loper Bright* for the first time, or at least clarify the MQD's applicability in *Chevron*'s absence.[184] Furthermore, *Loper Bright* instructs courts to apply the "best reading," or the "the reading the court would have reached if no agency were involved,"[185] to resolve statutory ambiguities.[186] Therefore, *Loper Bright* arguably leaves no room left for the MQD to operate since the "best reading" of a statute would logically preclude deferring to an agency's interpretation if the relevant statute does not explicitly grant the necessary authority to regulate the applicable significant economic and political matters.[187] On the other hand, the MQD could still be a separate tool in the statutory interpretation toolbox.[188]

Furthermore, *Loper Bright* may or may not be the correct doctrine for Courts to apply when determining whether to defer the NRC's interpretation of its statutes. On the one hand, since *Chevron* does not typically apply to the NRC, it follows that *Loper Bright* would not either. In fact, in July 2024, the NRC confirms it feels the same. The NRC's response letter to a Post-*Chevron* working group stated that:

> The NRC did not undertake specific work to prepare for the Court's holding in *Loper Bright* because the NRC has not generally relied on *Chevron U.S.A. Inc. v. Natural Resources*

---

should defer to an agency's interpretation of an ambiguous statute so long as the interpretation is not "arbitrary, capricious, or manifestly contrary to the statute." *Chevron U.S.A. Inc. v. Natural Resources Defense Council, Inc.*, 467 U.S. 837, 844 (1984). *See also, West Virginia v. EPA*, 597 U.S. 697, 724-25 (2022) (Kagan, E., dissenting) (pointing out the carveout because the majority's analysis only quoted half a sentence that "[f]or anyone familiar with this Court's *Chevron* doctrine, [the missing half of the sentence] will ring a bell. The Court was saying only—and it was elsewhere explicit on this point—that there was reason to hesitate before giving FDA's position *Chevron* deference."); *see also.*, Richard J. Pierce, Jr., *Two Neglected Effects of Loper Bright,* REGUL. REV. (July 1, 2024), https://www.theregreview.org/2024/07/01/pierce-two-neglected-effects-of-loper-bright/#:~:text=Moreover%2C%20the%20Loper%20Bright%20opinion,policy%20making%20power%20on%20agencies.

[180] *See* The Atomic Energy Act, 42 U.S.C. § 2201 (2024); *See e.g.*, U.S. NUCLEAR REGUL. COMM'N, RESPONSE TO QUESTIONS FROM THE POST-CHEVRON WORKING GROUP (July 11, 2024). *Chevron* (which was recently overturned) deference comes from a 1984 case and provides the notion that courts should defer to an agency's interpretation of an ambiguous statute so long as the interpretation is not "arbitrary, capricious, or manifestly contrary to the statute." *Chevron U.S.A. Inc. v. Natural Resources Defense Council, Inc.*, 467 U.S. 837, 844 (1984).

[181] *Loper Bright Enterprises* v. *Raimondo*, 603 U.S. ——, 144 S.Ct. 2244, (2024).

[182] *See e.g.*, Richard J. Pierce, Jr., *Two Neglected Effects of Loper Bright*, REGUL. REV. (July 1, 2024), https://www.theregreview.org/2024/07/01/pierce-two-neglected-effects-of-loper-bright/#:~:text=Moreover%2C%20the%20Loper%20Bright%20opinion,policy%20making%20power%20on%20agencies; *See Mayfield v. United States Department of Labor*, 117 F.4th 611, 616 (5th Cir. 2024) (explaining "whether the doctrine is one interpretative tool among many or a clear-statement rule is the subject of ongoing debate" and calling this conundrum a "heady question.").

[183] *Friends of the Floridas v. Bureau of Land Mgmt*., No. CIV-20-0924 JB/GBW, 2024 WL 3952037, at *60 (D.N.M. Aug. 27, 2024); *Compare Biden v. Nebraska*, 600 U.S. 477, 143 S. Ct. 2355, 2368-75, 216 L. Ed. 2d 1063 (2023) (Barrett, J., concurring) (applying the doctrine in conjunction with traditional interpretative tools), *and* (explaining that the major questions doctrine is a textual tool that emphasizes context, not a substantive canon), *with West Virginia*, 597 U.S. at 724-32 (2022) (starting with the major questions doctrine and arguably treating it as a substantive canon), *and id.* at 735 (Gorsuch, J., concurring) (arguing that the doctrine is a clear-statement rule).

[184] PATRICK JACOBI, ADMINISTRATIVE LAW AFTER *LOPER BRIGHT ENTERPRISES V. RAIMONDO* (Aug. 2024), https://www.yalejreg.com/nc/administrative-law-after-loper-bright-enterprises-v-raimondo-by-patrick-jacobi/

[185] *Loper Bright Enterprises* v. *Raimondo*, 603 U.S. ——, 144 S.Ct. 2244, 2266 (2024) (internal citations omitted).

[186] *Loper Bright Enterprises* v. *Raimondo*, 603 U.S. ——, 144 S.Ct. 2244, 2263 (2024).

[187] *See West Virginia v. EPA*, 597 U.S. 697, 716, 721 (2022).

[188] *See Mayfield v. United States Department of Labor*, 117 F.4th 611, 616 (5th Cir. 2024)

> *Defense Council, Inc*. to support its statutory interpretations underlying our regulatory process in recent years. Going forward…the NRC expects that holding will have a minimal impact on our regulatory activities.[189]

On the other hand, however, the *Loper Bright* opinion itself cited to a provision of the AEA in a footnote as an example of a statute that expressly delegates "to an agency the authority to give meaning to a particular statutory term."[190] The statutory provision *Loper Bright* cited to was 42 U.S.C. § 5846(a)(2), which indeed specifically states that the NRC can determine when a facility or activity licensed under the AEA "contains a defect which could create a substantial safety hazard, *as defined by regulations which the Commission shall promulgate*[.]"[191] However, the relevant statutory provisions related to nuclear materials are far less explicit than the AEA provision cited in *Loper Bright*. Accordingly, the Court could find the statutory provisions underlying the NRC's authority to license private offsite CISFs ambiguous, and if it does, how it will determine the bounds of the discretion owed to the NRC remains an open question.

VI. Conclusion

The Supreme Court's decision in *Texas v. NRC* could have resounding implications on the development of nuclear power in the U.S. If the Supreme Court finds that the AEA provisions do not permit the licensing of *any* interim storage facility in the absence of a federal repository all efforts to construct consolidated facilities would cease. This would render moot state efforts like those in Wyoming to explore CISFs until the U.S. develops a permanent repository or the law is amended to explicitly allow the NRC to license private CISFs or a federally owned CISF. However, even if the court finds that the NRC has the authority to license private CISFs, in the absence of a consent-based process, the construction and operation of those facilities is still not assured. The developers will still need to overcome state moratoria and local opposition.

Continued failure to act, however, is not a solution. Not only are onsite facilities limited in their capacity, but the failure to develop long terms storage solution may also impede progress towards climate goals. Nuclear power production is anticipated to expand as to meet growing demand for zero-carbon heat and power.[192] In 2021 Congress passed the Bipartisan Infrastructure Law, allocating $3.3 billion to the DOE to advance new nuclear reactor technologies.[193] In 2021, the DOE granted $160 million in funding to two advanced reactors that could be operational within five to seven years after funding, one of which is the reactor sited in Kemmerer, Wyoming.[194] Subsequently in 2024, the DOE announced that it made $800 million available to deploy two more novel nuclear reactor projects within the next ten years.[195] These facilities will generate SNF, adding to the existing problem.[196] Beyond this, failure to site storage facilities may thwart the development of these technologies altogether. Research shows that public perceptions of nuclear are closely related to concerns regarding the lack of a permanent waste solution and that communities are less likely to support nuclear facilities if they think those communities will become de-facto permanent storage sites for SNF.[197] Action is therefore necessary to promote both ongoing reactor operations and emissions reduction objectives.

[189] U.S. NUCLEAR REGUL. COMM'N, RESPONSE TO QUESTIONS FROM THE POST-CHEVRON WORKING GROUP (July 11, 2024).
[190] *Loper Bright Enterprises* v. *Raimondo*, 603 U.S. —— , 144 S.Ct. 2244, 2263 (2024).
[191] *Loper Bright Enterprises* v. *Raimondo*, 603 U.S. —— , 144 S.Ct. 2244, 2263 (2024) (citing 42 U.S.C. § 5846(a)(2) (2023) (emphasis added by the Court).
[192] DUNCAN ET AL., CTR. FOR ESG & SUSTAINABILITY, SOLVING THE ENERGY TRILEMMA: THE CASE FOR NUCLEAR AS A SUSTAINABLE INVESTMENT 2-4 (2022), https://img1.wsimg.com/blobby/go/3ee604fd-59ca-4062-82ff-38c3b80e4f96/Solving%20the%20Energy%20Trilemma-The%20Case%20for%20Nucle.pdf.
[193] U.S. DEP'T OF ENERGY, OFF. OF NUCLEAR ENERGY, DE-FOA-0002271, ADVANCE REACTOR DEMONSTRATION FUNDING OPPORTUNITY ANNOUNCEMENT (2020).
[194] *Id*.
[195] This funding opportunity also announced $100 million for subsequent projects to develop faster deployment support for the first two projects. U.S. DEP'T OF ENERGY, OFF. OF CLEAN ENERGY DEMONSTRATIONS, DE-FOA-0003485, BROAD AGENCY ANNOUNCEMENT: GENERATION III+ SMALL MODULAR REACTOR PATHWAY TO DEPLOYMENT 4 (2024).
[196] Stephen Singer, *Dive Brief: Managing NuScale, other SMR waste will be 'roughly comparable' with conventional reactors, DOE labs find*, UTILITY DIVE, Nov. 23, 2022, https://www.utilitydive.com/news/smr-modular-reactor-nuclear-waste-doe-stanford-study-nuscale/637185/; Lindsay M. Krall et al., *Nuclear waste from small modular reactors*, PROC. NAT'L ACAD. SCI., June 2022; Mark Shwartz, *Stanford-led research finds small modular reactors will exacerbate challenges of highly radioactive nuclear waste*, STANFORD REPORT (May 30, 2022), https://news.stanford.edu/stories/2022/05/small-modular-reactors-produce-high-levels-nuclear-waste#:~:text=%E2%80%9COur%20results%20show%20that%20most,at%20Stanford%20University%27s%20Center%20for.
[197] *See* IDAHO NAT'L LAB'Y ET AL., INL/RPT-23-71733, MICROREACTOR APPLICATIONS IN U.S. MARKETS: EVALUATION OF STATE-LEVEL LEGAL, REGULATORY, ECONOMIC AND TECHNOLOGY IMPLICATIONS 71 (2023).

REDUCING THE NUCLEAR TAX BURDEN: A SUMMARY OF TEXAS PROPERTY TAX INCENTIVES AVAILABLE TO NUCLEAR ENERGY PROJECTS*

David J. Sewell
Stahl, Sewell, Chavarria, Friend & Cohen, LLP
Austin, Texas

* David J. Sewell is a partner with Stahl, Sewell, Chavarria, Friend & Cohen, LLP in Austin, Texas, where he practices in the areas of renewable energy law, commercial real estate law, and Texas state tax litigation and consulting. Mr. Sewell has represented energy companies for over twenty-five years on projects throughout the United States. His practice focuses on real estate issues and issues related to state taxation. You can contact Mr. Sewell at dsewell@sbaustinlaw.com or (512) 652-2945.

I. INTRODUCTION

Pursuing property tax incentives has become an integral part of many different types of real estate projects in Texas, and energy projects are no exception. Whether the energy project is a renewable energy facility, a gas-fired power plant, a green fuels manufacturing facility, or a natural gas liquefaction facility, successfully negotiating one or more property tax incentive agreements is an expected part of the project's asset package. As discussions increase surrounding the viability of nuclear energy plants in Texas, developers and investors should understand the property tax incentives that are available to nuclear projects.

This paper reviews the principal types of property tax incentives that are offered in Texas and how they may be useful to nuclear energy developers. It is important for the developer's Texas tax counsel to understand both the types of tax incentives offered in Texas and the steps required to comply with the technical processes for obtaining enforceable incentive agreements.

II. TAX CODE CHAPTER 312 – TAX ABATEMENT AGREEMENTS

Texas Tax Code Chapter 312, the Property Redevelopment and Tax Abatement Act, provides for the abatement of property taxes on eligible property. All local taxing jurisdictions except school districts are eligible to enter into Chapter 312 agreements.[1] The current version of Chapter 312 sunsets on September 1, 2029.[2]

Chapter 312 of the Tax Code is structured in an odd way that can make it difficult to review and apply. Subchapter A of the statute addresses general items and matters of eligibility for tax abatements. Subchapter B addresses tax abatement agreements entered into by municipalities. Subchapter C addresses tax abatement agreements entered into by counties, but most of the provisions in Subchapter C refer back to and incorporate the code sections applicable to municipalities in Subchapter B. This cross-referential nature of Chapter 312 can create confusion and lead to procedural errors in pursuing Chapter 312 agreements. In addition, one section Subchapter A—Section 312.206—is the only part of the statute that addresses agreements entered into by taxing units other than municipalities and counties. The ensuing subsections of this paper clarify these aspects of Chapter 312 agreements: (A) the prerequisites for an agreement, (B) the tax incentive available to the taxpayer, (C) an agreement's requirements and limitations, (D) the process for entering into the agreement, and (E) special provisions for taxing units other than municipalities and counties.

A. Prerequisites.

A taxing unit must take two preliminary steps prior to executing a tax abatement agreement—adopt a resolution stating that the taxing unit is eligible to enter into agreements governed by Chapter 312 and adopt guidelines and criteria that will govern its abatement agreements.[3] These steps should be completed at a public hearing with the opportunity for public comment.[4] The "eligibility resolution" is understood to be a one-time act while guidelines and criteria are effective for only a two-year period and must thereafter be renewed for successive two-year periods.[5]

The hardwired expiration of the guidelines and criteria presents the first potential trap for nuclear energy project developers. Project developers must make sure that the taxing unit's guidelines and criteria have not expired before taking any formal action in pursuit of the tax agreement. If the guidelines and criteria have expired, the taxing unit can either reauthorize the prior version for an additional two-year period or adopt new guidelines and criteria; regardless of the path chosen, the action should be

[1] Tex. Tax Code § 312.002(g).
[2] Tex. Tax Code § 312.006.
[3] Tex. Tax Code § 312.002(a).
[4] Tex. Tax Code § 312.002(c-1).
[5] Tex. Tax Code § 312.002(c).

taken in a public meeting. Guidelines and criteria already in effect can be amended by the taxing unit, but the Tax Code requires a three-quarters vote in order to approve amendments.[6] The taxing unit's guidelines and criteria may establish an application process for tax abatement agreements and require an application fee not to exceed $1,000.[7]

Nuclear energy project developers should review the adopted guidelines and criteria in detail to ensure that they do not contain any obstacles to the proposed development. For example, some forms of guidelines and criteria restrict the types of projects for which the taxing unit may enter into a tax abatement agreement. Nuclear developers will want to make sure that their proposed projects are not excluded. Also, because the construction period for a nuclear project will be longer than many other types of developments, developers will also want to make sure that the guidelines and criteria do not impose any deadlines on either the commencement of project construction or the beginning of the ten-year abatement period.

The first official project-specific act that the nuclear developer will likely pursue is the designation of a reinvestment zone. A taxing unit may only grant a tax abatement to eligible property that is located in or will be located in a designated reinvestment zone.[8] Only school districts, municipalities, and counties have the authority to designate reinvestment zones.[9] Chapter 312 adopts a formal process for a municipality or county to designate a reinvestment zone while the process for the school district is less detailed. In practice, nuclear project developers who are seeking tax abatements from a municipality or a county will likely apply to the municipality or the county for the designation of the reinvestment zone. School districts were originally granted the right to designate reinvestment zones primarily in connection with Tax Code Chapter 313 value limitation agreements. Because the Chapter 313 statute has now expired, it is unlikely that taxpayers will approach school districts for the designation of a reinvestment zone in connection with a Chapter 312 tax abatement agreement.

Sections 312.201 and 312.401 describe the process for designating a reinvestment zone by a municipality and county, respectively. In order to designate the zone, the taxing unit must (1) hold a public hearing on the designation, and (2) at least seven days prior to the scheduled meeting, both publish notice of the hearing in a newspaper having general circulation in the taxing unit, and deliver written notice of the scheduled meeting to the presiding officers of the governing bodies of all other taxing units that have the authority to assess ad valorem taxes on the land included in the proposed zone.[10]

Chapter 312 also requires the taxing unit to make certain formal findings at the time that the reinvestment zone is designated. With respect to reinvestment zones designated by a municipality, section 312.201(d) requires that the municipality adopt a finding that "that the improvements sought [for the zone] are feasible and practical and would be a benefit to the land to be included in the zone" and to the taxing unit.[11] A reinvestment zone designation by a municipality should also recite the reinvestment zone criteria listed in § 312.202. Reinvestment zones designated by a county require a different finding—that the "designation [of the zone] would contribute to the retention or expansion of primary employment or would attract major investment in the zone that would benefit the property to be included in the zone and would contribute to the economic development of the county."[12] The conservative course of action for nuclear project developers will be to request that the taxing unit, whether municipality or county, adopt both sets of required findings in its reinvestment zone designation. The designation is typically documented in the form of a resolution, and the taxpayer should retain a copy of the resolution for its records.

Designated reinvestment zones expire five years after the date of designation, but the expiration of a reinvestment zone does not affect the enforceability of a tax abatement agreement that is entered into during the five-year window after designation.[13] Property may be located both in a reinvestment zone designated by a municipality and a reinvestment zone designated by a county.[14] The Texas Attorney General has opined that, once designated, reinvestment zones may not be amended.[15] The same opinion finds that all of the land included in a single designated reinvestment zone must be contiguous.[16]

This Attorney General's Opinion (DM-456) presents another opportunity for a misstep. If a nuclear project developer successfully petitions a municipality or county to designate a reinvestment zone and later discovers

[6] Tex. Tax Code § 312.002(c).
[7] Tex. Tax Code § 312.002(e).
[8] Tex. Tax Code §§ 312.204(a), 312.206(a), 312.402(a).
[9] Tex. Tax Code §§ 312.0025, 312.201, 312.401.
[10] Tex. Tax Code §§ 312.201(d), 312.401(b).
[11] Tex. Tax Code § 312.201(d).
[12] Tex. Tax Code § 312.401(b).
[13] Tex. Tax Code §§ 312.203, 312.401(c).
[14] Tex. Tax Code § 312.401(d).
[15] *See* Op. Tex. Att'y Gen. No. DM-456 (1997).
[16] *See Id.*

that it needs to add land to the reinvestment zone to accommodate its project, the developer might logically be tempted to request an amendment of the reinvestment zone already designated. But if an amendment is approved, it would violate the legal analysis in the Attorney General's Opinion and potentially invalidate the reinvestment zone designation and, *ipso facto*, any tax abatement agreement entered in reliance on the reinvestment zone. In lieu of seeking an amendment to the reinvestment zone, the developer should petition for the designation of a second reinvestment zone for the project land that is not already included in the first zone. There is no restriction on an abatement agreement abating taxes on eligible property located in more than one reinvestment zone.

Taxpayers often seek multiple tax abatement agreements for the same project. For example, a project developer may pursue a tax abatement agreement with a county, a county hospital district, a water district, and a junior college district. This is permissible and common. Taxpayers should ensure that every taxing unit complies with the prerequisites of electing eligibility to participate in tax abatement and adopting guidelines and criteria; however, only a school district, municipality, or county is authorized to designate a reinvestment zone. Other types of taxing units must rely on the designation by one of these entities when granting their tax abatements.

Chapter 312 prohibits property owned by persons who are members of a municipality's governing body, members of a municipality's zoning or planning body, or members of a county's commissioners court from benefitting from a tax abatement agreement.[17] The Texas Attorney General has opined that these provisions of Chapter 312 do not prohibit an energy project from receiving an abatement for improvements and tangible personal property installed on real property that is leased from a government official.[18] In this case, the government official's ownership of the leased real property does not invalidate an abatement granted for tangible personal property and improvements to be installed on the leased real property. Further, if a prohibited government official acquires property that is already subject to an existing tax abatement agreement, the abatement agreement is not invalidated.[19]

B. The Tax Incentive Available.

Tax Code Chapter 312 permits taxing units to grant abatements from ad valorem taxes for a variety of property types. The tax abatement can exempt any portion—up to 100%—of the value of the eligible property from ad valorem taxes for a period not to exceed ten years.[20] The property benefitting from the abatement agreement may include taxable real property owned by the taxpayer and improvements and tangible personal property to be constructed and installed on the real property; the leasehold interest, improvements to be constructed, and tangible personal property to be installed on tax-exempt real property by a lessee of the real property; and improvements to be constructed and tangible personal property to be installed on taxable real property by a lessee of the real property.[21] Chapter 312 also expressly authorizes municipalities to approve abatement agreements affecting property located in their extraterritorial jurisdictions.[22] In the case of an abatement agreement executed for a project in an ETJ, the agreement is prospective in nature, and the abatement will only apply if the municipality ultimately annexes the property (and therefore begins assessing ad valorem taxes on the property) during the abatement period established in the agreement.[23]

Depending on the type of property receiving the abatement, different limitations on the abatement may apply. If the abatement is granted to the owner of real property and real property improvements, then the abatement percentage may only be applied to the amount by which the real property's future taxable value exceeds its taxable value for the year in which the agreement is executed.[24] If taxes on tangible personal property, such as equipment, will be abated, then the abatement may not apply to any tangible personal property located on the real property prior to the execution of the abatement agreement.[25] Taxes may be abated on a percentage, up to 100%, of the full taxable value of tangible personal property installed in the reinvestment zone after the execution of the abatement agreement.

Because nuclear energy projects are likely to be comprised of both real property improvements and tangible personal property (in the form of removeable equipment), the taxpayer will need to properly characterize the different components of the project into real property and tangible personal property in order to model the overall value of its

[17] Tex. Tax Code §§ 312.204(d), 312.402(d).
[18] *See* Op. Tex. Att'y Gen. No. GA-0600 (2008).
[19] Tex. Tax Code §§ 312.204(d), 312.402(d).
[20] Tex. Tax Code §§ 312.204(a), 312.402(a).
[21] Tex. Tax Code §§ 312.204(a), 312.402(a), (a-1), (a-3).
[22] Tex. Tax Code § 312.201(c).
[23] Tex. Tax Code § 312.201(c).
[24] Tex. Tax Code §§ 312.204(a), 312.402(a-2).
[25] Tex. Tax Code §§ 312.204(a), 312.402(a-2).

incentive. The relevant legal question is: Which project materials will become permanent attachments to real property after construction of the project is completed, and which materials will retain their character as tangible personal property? Texas Comptroller hearings consistently apply the traditional common law test for determining whether tangible personal property has become a permanent attachment to real property. The common law test, as recited in the Texas Supreme Court case of *Hutchins v. Masterson & Street*,[26] applies the following three factors: the extent of annexation of the tangible personal property to the realty, the degree to which the tangible personal property was adapted to the realty, and the intention of the party that annexed the property to the realty.[27] The holding in *Hutchins* ultimately provides: "And of these three tests, pre-eminence is to be given to the question of intention to make the article a permanent accession to the freehold, while the others are chiefly of value as evidence as to this intention."[28]

One instructive Comptroller Hearing that decided the question of whether repair and maintenance services were performed on real property or tangible personal property closely follows the *Hutchins* test. The hearing decision describes the analysis as follows: "In making this distinction [between real and personal property], the Comptroller has looked to the intention of the parties, the extent to which the property is annexed to the real property, and the degree of fitness or adaptation to the purposes of the realty. Intent is the preeminent factor, and the other two factors are evidence of intent. The determination in each case is dependent upon the particular facts and circumstances of the case."[29]

An earlier Comptroller letter ruling provides additional helpful analysis. In the letter ruling, the Comptroller was asked whether radio towers bolted to foundations and supported by cables that were anchored to concrete cylinders imbedded six-to-ten feet below ground were real property or personal property. Although the Comptroller did not respond with a definitive answer to the question posed by the taxpayer, the letter provides a description of how the question is analyzed under Texas law. The letter cites the three *Hutchins* factors, and in accordance with the *Hutchins* holding, focuses on the intent of the parties. The letter ruling advises, first, that "items bolted to such foundations are not considered to be 'a real or constructive annexation to the realty' and therefore not improvements to realty regardless of the size of the item and the stability of the bolts," and second, that because radio towers are often installed on leased property, the intent of the parties is "clearly evident when mentioned in the [lease] contract."[30] Nuclear project developers should be able to rely on this letter ruling and take the position that all equipment bolted to foundations retains its character as tangible personal property.

For the nuclear project developer, the replaceability of components—both the intention of being able to replace them and the degree of difficulty of replacing them (including whether they are merely bolted to a foundation)—are the primary analyses that should be employed to properly delineate between project improvements that are taxed as real property and project improvements that are taxed as personal property. Further, if the nuclear project is constructed on land pursuant to a long-term ground lease, negotiated language in the ground lease should be respected as evidence of the lessor's and lessee's intent with respect to the permanence of project improvements. The primary concern for the Chapter 312 tax abatement agreement is that, for project improvements that are characterized as real property, only the amount by which the real property's value in any abatement year exceeds its taxable value for the year in which the agreement is executed may be abated.[31]

C. The Abatement Agreement's Requirements and Limitations.

Tax Code § 312.205(a) provides some specific provisions that must be included in a tax abatement agreement entered into by a municipality, and § 312.402(a-2) mirrors (by cross-reference) the same requirement for county agreements. A tax abatement agreement must: (1) list the kind, number, and location of all proposed improvements on the property; (2) provide access to and authorize inspection of the property by government employees to ensure that the improvements or repairs are made according to the specifications and conditions of the agreement; (3) limit the uses of the property consistent with the general purpose of encouraging development or redevelopment of the reinvestment zone during the period that property tax abatements are in effect; (4) provide for recapturing property tax revenue lost as a result of the agreement if the taxpayer fails to make the improvements or repairs as provided by the agreement; (5) contain each term agreed to by the taxing unit and the taxpayer; (6) require the owner of the property to certify annually to the

[26] *Hutchins v. Masterson & Street*, 46 Tex. 551 (1877).
[27] *Id*. at 554.
[28] *Id.*
[29] Comptroller Hearing 43,798 (2004) (STAR Doc. 200412078H) (citations omitted).
[30] Comptroller Letter Ruling 9409L1321D04 (Sep. 9, 1994) at 2.
[31] Tex. Tax Code §§ 312.204(a), 312.402(a-2).

governing body of each taxing unit that the owner is in compliance with each applicable term of the agreement; and (7) provide that the governing body of the municipality may cancel or modify the agreement if the property owner fails to comply with the agreement.[32] The tax agreement may also be conditioned on the taxpayer completing certain improvements or installing certain property.[33] The project developer's counsel should ensure that each required provision is included in the final abatement agreement.

Two key negotiable elements of a tax abatement agreement are the percentage and length of the abatement granted. As previously noted, the period of abatement may be up to ten years.[34] One useful provision of the statute authorizes the parties to defer the commencement of the abatement period.[35] In the event of a deferred commencement date, it is common for an agreement to provide that the tax abatement period will be begin on January 1 of the year following the year during which an agreed-upon event occurs, for example, the commencement of project construction or the commencement of commercial operations of a project. Applicants are sometimes even able to negotiate for the right to choose when to begin the ten-year abatement.

Structuring the ten-year abatement period for a nuclear energy project will require careful planning by the developer and its tax consultants. The question facing developers is: During which ten years will the project be the most valuable from an ad valorem tax perspective? The developer will want to structure the abatement agreement in a way that will permit it to elect for these ten years to comprise the abatement period. All of the tangible personal property installed in the reinvestment zone prior to the commencement of the ten-year abatement period will be subject to ad valorem taxes at its full fair market value until the abatement period commences. Likewise, if the increase in value of real property is subject to abatement, the full value of the real property (including project-related increases) will be taxable before the abatement period commences. For these reasons, the project developer may be required to pay significant amounts of property tax before the ten-year abatement becomes effective. These issues illustrate the valuable benefit of negotiating for an abatement structure where the developer is allowed to choose the year the abatement period commences. Only by having this right will developers ensure that they have the opportunity to achieve the greatest amount of tax savings.

Chapter 312 permits a taxing unit to abate up to 100% of the value of the described property from taxation. Some taxing units prefer to approve abatements based on an agreed percentage, such as an 80% abatement over ten years, while others prefer to agree to a formula that will be used to calculate an abatement percentage. There is no requirement that the abatement percentage remain static during the abatement period or that the percentage be a fixed number. Some taxing units prefer to enter into agreements that abate 100% of the value of the property from taxation in exchange for a mandatory "payment in lieu of taxation" (PILOT) that will be paid by the taxpayer. The PILOT structure may be preferred by the taxing unit because it converts a potentially variable tax payment based on fair market value over a ten-year period into a fixed stream of payments. Chapter 312 does not favor, disfavor, or prohibit any of these abatement types. The amount, length, and form of tax incentive to be received by the taxpayer are fully negotiable except that (i) abatement periods may not be longer than ten years, and (ii) agreements made with owners of property in the same reinvestment zone must contain identical terms for the abatement percentage and length of abatement period.[36] This second limitation provides an incentive for taxing units to designate reinvestment zones that include only the real property to be developed as part of the project receiving the abatement. As a result, later-arriving developers will be required to seek their own reinvestment zones, and the taxing unit will not be bound by the precedent of prior abatement agreements when negotiating with later-arriving developers.

Tax Code § 312.205(b) provides some specific terms that may be included in a tax abatement agreement entered into by a municipality, and § 312.402(a-2) incorporates the provision for County agreements. A tax abatement agreement may: (1) provide for certain infrastructure improvements to be made by the developer; (2) require the submission of an economic feasibility study; (3) require the submission of detailed maps of the proposed improvements; (4) identify proposed changes to zoning ordinances, master plans, building codes, or other applicable ordinances or regulations; and (5) include the remedy of recapturing all abated taxes in the event of a default by the developer.[37] As a practical matter, all abatement agreements will include the recapture remedy. The developer's counsel should negotiate reasonable notice and cure provisions and propose to include a provision that makes the recapture of abated taxes the taxing unit's sole monetary remedy.

Outside of § 312.205(a) and (b) and § 312.402(a-2), Chapter 312 provides little guidance concerning the

[32] Tex. Tax Code § 312.205(a).
[33] Tex. Tax Code §§ 312.204(a), 312.402(a-2).
[34] Tex. Tax Code §§ 312.204(a), 312.402(a).
[35] Tex. Tax Code § 312.007.
[36] Tex. Tax Code § 312.204(b).
[37] Tex. Tax Code § 312.205(b).

form of an agreement or other types of provisions that may be included in an agreement. Some taxing units may use an abatement agreement as a vehicle for imposing land-use restrictions and regulations such as setbacks, screening requirements, restrictions on lighting, restoration obligations, safety regulations and obligations, and other similar types of restrictions or regulations. An abatement agreement may also require the submission of plans, studies, and other project due diligence and impose a type of review and approval process to be overseen by the taxing unit. To the frustration of project developers, taxing units insisting on such provisions will likely be negotiating for regulatory powers not otherwise granted to them by Texas law, but ultimately, the inclusion of such provisions in an abatement agreement is not prohibited by Chapter 312.

D. The Approval Process for an Abatement Agreement.

Once a reinvestment zone has been designated and the terms of an abatement agreement have been negotiated, the taxing unit must follow a promulgated process for approving and executing the agreement. Abatement agreements must be approved at a public meeting.[38] Written notice of the meeting must be delivered to the presiding officer of the governing body of each taxing unit that has the authority to tax the land included in the reinvestment zone at least seven days prior to the meeting date.[39] The notice must include a copy of the proposed form of agreement.[40] Although the statute indicates that this notice is mandatory, it also provides that failure to deliver the notice will not invalidate the agreement.[41] In 2019 the Texas legislature passed an amendment to Chapter 312 that requires an additional form of notice be given by the taxing unit. This new amendment requires that, at least thirty days prior to the scheduled meeting at which the agreement will be approved, the taxing unit must publish a notice containing (i) the name of the property owner and applicant for the tax abatement, (ii) the name and location of the reinvestment zone, (iii) the general description of the improvements included in the agreement, and (iv) the estimated cost of the improvements.[42] The notice must be posted in the same manner that the taxing unit posts regular meeting notices (i.e., on the bulletin board in the area for public meeting notices and on the internet if the taxing unit utilizes electronic meeting postings).[43]

The abatement agreement must be approved by a majority of the voting members of the taxing unit's governing body and, upon approval, may be executed in the same manner as any other contract entered into by the taxing unit.[44] After an agreement is entered into, it may be modified or amended by the parties using the same procedure by which the agreement was originally approved.[45] The agreement may also be terminated by mutual consent.[46]

E. Special Considerations for Abatement Agreements by Other Tax Units.

Tax Code 312.206 governs tax abatement agreements approved by "other taxing units," that is, taxing units other than municipalities and counties. These "other taxing units" may include hospital districts, junior college districts, water districts, road districts, and any other taxing units that are governed by their own independent governing bodies—but not school districts. School districts are not authorized to execute Chapter 312 agreements.[47] Prior to entering into a tax abatement agreement, each "other taxing unit" must complete the Chapter 312 prerequisites of electing eligibility to participate in tax abatement and adopting guidelines and criteria.[48]

Governing bodies of other taxing units have two options for entering into tax abatement agreements. Section 312.206(a) provides that another taxing unit may, prior to a municipality or county entering into a tax abatement agreement, indicate its desire to be bound by the terms of the municipal or county agreement.[49] If the other taxing unit makes this election, then upon the municipality or county entering into the agreement, the terms of the agreement will automatically apply to the other taxing unit.[50]

A more common approach is that the other taxing unit will negotiate its own tax abatement agreement. In this case, the agreement may abate taxes on the same types of property for which a municipality and county may abate taxes.[51] Although the agreement with another taxing unit is required to contain all of the specific terms listed in section 312.205, the agreement is not required to grant the same percentage of abatement or length of abatement

[38] Tex. Tax Code §§ 312.207(a), 312.404.
[39] Tex. Tax Code § 312.2041(a).
[40] Tex. Tax Code § 312.2041(a).
[41] Tex. Tax Code § 312.2041(c).
[42] Tex. Tax Code § 312.207(c).
[43] Tex. Tax Code § 312.207(c).
[44] Tex. Tax Code §§ 312.207(a)-(b), 312.404.
[45] Tex. Tax Code § 312.208(a).
[46] Tex. Tax Code § 312.208(b).
[47] Tex. Tax Code § 312.002(g).
[48] Tex. Tax Code § 312.002(a).
[49] Tex. Tax Code § 312.206(a).
[50] Tex. Tax Code § 312.206(a).
[51] Tex. Tax Code § 312.206(a).

granted by the municipality or the county.[52] Further, the other taxing unit may approve a tax abatement agreement with the taxpayer even if the municipality or county elects not to approve an abatement.[53] The only limitation placed on the other taxing unit is that the other taxing unit is not authorized to designate a reinvestment zone, so it must rely on a reinvestment zone designated by the municipality or the county. This limitation makes obtaining an abatement agreement with another taxing unit impossible without the support of the municipality or county where the project site is located. If the municipality and county want to obstruct the project, they can effectively prevent the granting of an abatement by another taxing unit by refusing to designate a reinvestment zone.

III. GOVERNMENT CODE CHAPTER 403, SUBCHAPTER T – "JETI" AGREEMENTS

The Texas Jobs, Energy, Technology, and Innovation Act, referred to as "JETI," was enacted by the 88th Legislature in House Bill 5 to be effective January 1, 2024. Because the JETI program is the only available tax incentive that applies to school district ad valorem taxes, the JETI program is generally considered to be the replacement for the expired Tax Code Chapter 313 program, but the two programs contain many differences. The JETI statute sunsets on December 31, 2033.[54] The ensuing subsections of this paper summarize key parts of the JETI statute: (A) the types of projects eligible for a JETI agreement, (B) the tax incentive available to the taxpayer under the statute, (C) key aspects of the JETI agreement, and (D) the process for entering into the agreement.

A. Projects Eligible for JETI Agreements.

A project must meet the definition of an "Eligible Project" in order to qualify for a JETI agreement. Under Government Code § 403.602(8), "Eligible Project" is defined to include the following categories of projects: (a) new facilities or expansions of facilities that are either (i) manufacturing facilities, (ii) facilities related to the provision of utility services, including electric generation facilities that are considered to be "dispatchable," (iii) facilities related to the development of natural resources, and (iv) facilities engaged in research, development, or manufacture of high-tech equipment or technology; and (b) new construction or expansion of critical infrastructure. With respect to electric generation facilities, "dispatchable" is described as the ability to control the facility's output primarily by forces under human control.[55] The definition of "Eligible Project" also contains a negative element where the statute clarifies that non-dispatchable electric generation facilities and electric energy storage facilities are not eligible for JETI agreements.[56] Based on these definitions, a nuclear energy project qualifies as a dispatchable electric generation facility.

The Texas Comptroller's administrative rules provide additional guidance on the definition of "Eligible Project" by matching North American Industry Classification System (NAICS) codes to the distinct parts of the statutory definition.[57] The comptroller rules reference the following NAICS codes sections:

- Manufacturing facilities: NAICS 31-33[58];
- Electric generation facilities: NAICS 2211 but only to the extent that the electricity generated is dispatchable;
- Facilities for the development of natural resources:
  - Agriculture, forestry, fishing, and hunting: NAICS 11, and
  - Mining, quarrying, and oil and gas extraction: NAICS 21; and
- Research and development facilities: NAICS 5417.

The comptroller rules also offer a non-exhaustive list of projects that could be considered "critical infrastructure." These projects include:

- Water-related facilities such as water intake structures, water treatment facilities, wastewater treatment plants, and pump stations (NAICS 2213);
- Liquid natural gas terminal or storage facilities (NAICS 424710);
- Pipelines and pipeline facilities, including CO2 treatment, storage, and processing and the liquefaction of gaseous substances (NAICS 486); and
- Utility-scale water or wastewater storage, treatment, or transmission facilities (NAICS 2213).

B. The Tax Incentive Available Under JETI.

All JETI agreements offer the same tax incentive to successful applicants. For the applicable ten-year "Incentive Period," the taxable value of all buildings and tangible personal property comprising the applicant's Eligible Project will be limited, solely for school district maintenance and operations (M&O) taxes, to either fifty

[52] Tex. Tax Code § 312.206(a), (c).
[53] Tex. Tax Code § 312.206(c).
[54] Tex. Gov't Code § 403.603.
[55] Tex. Gov't Code § 403.602(8)(A)(i)(b).
[56] Tex Gov't Code § 403.602(8)(B).
[57] The comptroller rules are codified in Title 34, Chapter 9 of the Texas Administrative Code.
[58] Note that NAICS 325120 for "Industrial Gas Manufacturing" includes hydrogen generation and the generation of other fuels that can be considered "green fuels."

percent of its market value taxes or, if the Eligible Project is located in a qualified opportunity zone, twenty-five percent of its market value.[59] The JETI agreement has no effect on the value of taxable property for school district interest and sinking fund (I&S) taxes. In addition, for each tax year beginning with the year after the year during which the JETI agreement is signed and continuing through the year that includes the construction completion date, the taxable value of the property included in the Eligible Project will be zero.[60] This is a significant difference between a JETI agreement and a Chapter 312 agreement where, under Chapter 312, the improvements are fully taxable until the commencement of the ten-year abatement period. The ten-year Incentive Period will be defined in the JETI agreement, but it may not begin earlier than the year following the construction completion date or be deferred later than ten years after the year in which the agreement is executed.[61]

C. Key Aspects of the JETI Agreement.

The comptroller has promulgated a form of application for a JETI agreement, and the application is available on the comptroller's website.[62] As of the date of publication of this paper, there have been ten JETI applications filed with the comptroller's office.[63] The types of proposed projects include jet fuel manufacturing, aircraft parts manufacturing, recycling facilities, a natural gas electricity generation plant, and manufacturing facilities for materials related to lithium-ion batteries. The comptroller is also tasked with promulgating a form for the JETI agreement, but the form was not adopted as of the publication date of this paper.

Although a JETI agreement form has not been promulgated, the statute describes some of the key provisions that must be included in an agreement. A JETI agreement will require that the applicant meet certain job creation and minimum investment requirements. The number of jobs to be created and the amount of the minimum investment requirement depend on the population of the county in which the Eligible Project will be located. If the Eligible Project will be located in more than one county, the jobs and investment requirements of the smallest county apply.[64] The jobs and investment requirements are:

- For a county with a population of at least 750,000: 75 jobs and a minimum investment of $200 million;
- For a county with a population between 250,000 and 749,999: 50 jobs and a minimum investment of $100 million;
- For a county with a population between 100,000 and 249,999: 35 jobs and a minimum investment of $50 million; and
- For a county with a population less than 100,000: 10 jobs and a minimum investment of $20 million.[65]

In order to qualify as "created jobs" under the JETI agreement, the jobs created by the developer must meet certain wage and health insurance coverage requirements.[66] Unlike the prior Chapter 313 statute, the JETI statute does not provide a mechanism for waiving or reducing the jobs requirement, but the statute does exempt electric generation facilities from complying with the jobs requirement.[67] Nuclear projects with JETI agreements will benefit from an exemption from the jobs requirement; therefore, nuclear projects will only be required to satisfy the minimum investment requirement for the county in which it is located. If an applicant fails to meet the jobs or wage requirement, it may be assessed a penalty, and the governor may terminate the agreement after applicable notice and cure periods.[68] The applicant is given broad latitude to demonstrate its compliance with the minimum investment requirement, but the statute provides a safe harbor—the requirement is deemed to be met if the appraised value of the project's property exceeds the investment requirement in the second tax year of the Incentive Period.[69]

Section 403.612 of the JETI statute lists other terms and conditions that must be included in the JETI agreement. In addition to requirements that the agreement identify the type of project, the Construction Period, the Incentive Period, and the applicable job, wage, and minimum investment requirements, the agreement must also contain a provision that prohibits the payment of any

[59] Tex. Gov't Code § 403.605(a). The Comptroller's website includes a link to a map of current qualified opportunity zones.
[60] Tex. Gov't Code § 403.605(b).
[61] Tex. Gov't Code § 403.613(a-b).
[62] *See* https://comptroller.texas.gov/economy/development/prop-tax/jeti/forms.php.
[63] *See* https://comptroller.texas.gov/economy/development/prop-tax/jeti/applications.php.
[64] Tex. Gov't Code § 403.604(e).
[65] Tex. Gov't Code § 403.604(b).
[66] Tex. Gov't Code § 403.612.
[67] Tex. Gov't Code § 403.604(a).
[68] Tex. Gov't Code §§ 403.612(d), 403.614.
[69] Tex. Gov't Code § 403.604(d).

amounts to the school district.[70] To reinforce this prohibition, the statute contains a punitive provision stating that if a district or person acting on behalf of a district solicits or accepts a payment from an applicant, or if an applicant or person acting on behalf of an applicant makes or offers to make a payment to a district, the attorney general may bring an action in Travis County District Court against the offending person or party.[71] This particular aspect of the JETI statute is a significant departure from the prior tax incentive available under Tax Code Chapter 313 where school districts were able to receive a direct financial benefit—in the form of supplemental payments—from the applicant. Other than an application fee, the JETI statute provides no direct financial benefits to the school district.

The JETI statute also requires that each agreement contain a provision obligating the applicant to post a performance bond with the comptroller "in an amount the comptroller determines to be reasonable and necessary to protect the interests of the state and the district."[72] The amount of the performance bond will be set by the comptroller. The JETI statute provides no direct guidance as to the amount of the performance bond or upon what circumstances the bond may be applied or accessed by the comptroller, but the comptroller administrative rules indicate that the amount of the performance bond will be ten percent of the estimated gross tax benefit to the applicant.[73]

The term of the JETI agreement will commence upon signing and expire on December 31 of the third year following the end of the Incentive Period.[74] The statute also requires the submission of biennial reports by all taxpayers that enter into a JETI agreement.[75] The biennial report form will be promulgated by the comptroller and will require sworn statements concerning compliance with the jobs, wages, and minimum investment requirements contained in the JETI agreement as well as other aspects of the Eligible Project.[76]

D. The Application Process for JETI Agreements.

The application process for JETI agreements involves three governmental agencies—the local school district, the Texas Comptroller, and the Texas Governor—and will likely take between 120 and 180 days to complete.[77] Unlike Chapter 313, applications for JETI agreements will be filed with the Texas Comptroller and not with the local school district.[78] Section 403.607(b) of the statute lists the items that must be included in the application, and the comptroller has promulgated a form of application that must be used.[79] In addition to a description of the proposed project and taxable property to be included in the project, the application must identify the proposed Construction Period, the proposed Incentive Period, the applicable jobs and investment requirements, and a summary of the economic benefits of the project.[80] The application will also require the creation of a reinvestment zone before the JETI agreement may be signed.[81] In addition to the application itself, the comptroller may require an application fee be paid to the comptroller's office, and an application fee not greater than $30,000 may be charged by the school district.[82] As of the date of publication of this paper, the comptroller's website indicates that the comptroller's office will not charge a JETI application fee.[83]

Separate from the application, the applicant must also submit an economic benefit statement that complies with § 403.608 of the statute. The economic benefit statement must estimate total jobs, total capital investment, increase in appraised value of property, total ad valorem taxes to be owed to all taxing units, other taxes to be paid in connection with the project, and other economic benefits that may be derived from the project.[84] The comptroller is given broad authority to require revisions to or supplementation of the economic benefit statement.[85]

After the comptroller receives an application and economic benefit statement that it has determined are complete, the comptroller has sixty days to determine whether or not to recommend the approval of an application to the governor and the school district.[86] The comptroller's recommendation to approve an application depends on it making four specific findings: (1) the application describes an Eligible Project, (2) the proposed project is reasonably likely to generate an amount of state and local tax revenue to offset the "lost" school district ad

[70] Tex. Gov't Code § 403.612(c).
[71] Tex. Gov't Code § 403.620.
[72] Tex. Gov't Code § 403.612(b)(9).
[73] 34 Tex. Admin Code § 9.5004(i)(2).
[74] Tex. Gov't Code § 403.612(b)(2).
[75] Tex. Gov't Code § 403.616.
[76] Tex. Gov't Code § 403.616.
[77] The comptroller's website links to a document that depicts the JETI timeline and process. *See* https://comptroller.texas.gov/economy/development/prop-tax/jeti/process.php.
[78] Tex. Gov't Code § 403.607(a).
[79] *See* https://comptroller.texas.gov/economy/development/prop-tax/jeti/forms.php.
[80] Tex. Gov't Code § 403.607(b).
[81] Tex. Gov't Code § 403.607(b)(13).
[82] Tex. Gov't Code § 403.607(d).
[83] *See* https://comptroller.texas.gov/economy/development/prop-tax/jeti/process.php.
[84] Tex. Gov't Code § 403.608(b).
[85] Tex. Gov't Code § 403.607(c-e).
[86] Tex. Gov't Code § 403.609(a), (d).

valorem taxes before the twentieth anniversary of the first day of the Construction Period, (3) the JETI agreement is a "compelling factor" in a competitive site selection determination and that, in the absence of the agreement, the applicant would not make the proposed investment in Texas, and (4) if the applicant represents that the project will be located in a opportunity zone, confirmation that the project site is located in the opportunity zone.[87] The statute provides that the comptroller "*shall* recommend an application for approval" if the comptroller makes the prescribed findings; therefore, it appears that the comptroller does not have discretion to disapprove an application that satisfies all four criteria.[88]

The "compelling factor" test in the JETI statute is considered to be a higher threshold than the "determining factor" test that was applied to applications under the now-expired Tax Code Chapter 313 program. The JETI statute requires that the applicant provide details concerning a competitive site selection process for the proposed project, meaning that a specific site outside of Texas must be identified as a location that was also considered for development.[89] The compelling factor test also requires a type of "but for" analysis where the comptroller must determine that the Eligible Project would not be constructed without a JETI agreement. In making this determination, the Comptroller is permitted to review a broad range of criteria, including workforce conditions, regulatory environment, infrastructure, and transportation.[90] The comptroller rules include additional factors such as official statements made by the applicant and previous applications by the applicant and subsequent granting of tax incentive agreements.[91] Notably, the Texas House of Representatives' version of the JETI statute contained an exception that permitted electric generation facilities, such as nuclear energy projects, to avoid the compelling factor analysis, but amendments made by the Texas Senate removed the exception. Based on the statute's description of the compelling factor test, nuclear project applicants should be prepared to submit detailed information concerning its site selection process with its JETI application, including identifying at least one non-Texas site that was considered for the project.

If the comptroller determines that the application should be recommended, then it will send its notice of recommendation, a copy of the application, and a copy of each document relied on by the comptroller in making its recommendation to the governor and the school district.[92] After receiving the comptroller's positive recommendation, each of the governor and the school district has thirty days to review the application materials and make its own independent decision on whether to enter into a JETI agreement.[93] The governor must notify the comptroller, the school district, the applicant, and the JETI oversight committee established under § 403.618 of the governor's decision within seven days after the decision is made.[94] The school district is required to hold a public meeting with a minimum fifteen-day public notice in order to review the application.[95] The school district must notify the comptroller, the governor, and the applicant of its decision to agree or not agree to enter into a JETI agreement.

If the governor and the school district both agree to the application, then the parties must proceed to negotiate the form of the agreement with the applicant. There is no statutory limit on how long the parties have to reach agreement on the terms of a JETI agreement. If the parties are able to successfully negotiate a JETI agreement, the agreement must be executed by the governor, the school district, and the applicant.

IV. LOCAL GOVERNMENT CODE CHAPTERS 380 AND 381 – ECONOMIC DEVELOPMENT AGREEMENTS

Local Government Code chapters 380 and 381 give municipalities and counties an alternative to granting a Chapter 312 abatement agreement. Note that these code chapters are not found in the Tax Code; this is because they do not directly implicate ad valorem taxes. Instead, Chapters 380 and 381 fall into the more general category of economic development agreements. Local Government Code chapter 380 applies to municipalities while chapter 381 applies to counties. While nothing in the Tax Code or the Local Government Code prohibits a municipality or county from entering into both a Chapter 312 abatement agreement and an economic development agreement under Chapter 380 or Chapter 381, in practice taxing units generally offer one or the other, and not both. Under most circumstances, the taxing unit will inform the developer of the type of incentive agreement that it will offer rather than permitting the developer to choose.

Chapter 380 and 381 agreements are sometimes referred to as "tax rebate" agreements, but this is really a misnomer. The idea that these agreements offer "rebates" comes from a common structure where, if a taxpayer

[87] Tex. Gov't Code § 403.609(b).
[88] Tex. Gov't Code § 403.609(a) (emphasis added).
[89] Tex. Gov't Code § 403.609(b)(3).
[90] Tex. Gov't Code § 403.609(c).
[91] 34 Tex. Admin. Code § 9.5004(f).
[92] Tex. Gov't Code § 403.609(e).
[93] Tex. Gov't Code §§ 403.610(a), 403.611(a).
[94] Tex. Gov't Code § 403.610(b).
[95] Tex. Gov't Code § 403.611(b, c).

performs to a certain level (i.e., generates a certain amount of sales tax revenue or pays a certain amount of property taxes), then the municipality or county will owe an economic incentive payment back to the taxpayer. The incentive payment is often measured, at least in part, by the amount of tax already paid or remitted by the taxpayer. Chapters 380 and 381 are uncomplicated statutes, and their simplicity permits creativity in negotiating inventive agreements. Using general language, the code provisions permit municipalities and counties to "make loans and grants of public money" to promote economic development.[96] For most energy projects, the local government will agree to make economic incentive payments to the property owner over a period not to exceed ten years. Chapters 380 and 381 do not limit the types of projects to which they can apply; therefore, nuclear energy projects are eligible for these economic incentive agreements.

The right to receive economic development payments in agreements entered into under Chapter 380 or Chapter 381 will typically be conditioned on the achievement of certain negotiated project parameters. Some of these parameters may include payment of a minimum amount of ad valorem property taxes, collection of a minimum amount of local sales taxes, and achieving certain employment levels based on total payroll, number of employees, or both. Different types of energy projects will commit to different types of parameters. For example, most electricity generation projects do not collect sales taxes because their sales of electricity are exempt from sales tax as sales-for-resale. So, Chapter 380 and 381 agreements for non-nuclear electricity generation projects have typically focused on property taxes and, in some cases, employment. Economic development agreements for nuclear projects are likely to follow a similar structure.

For many energy projects, the governmental entity and the taxpayer will refer to the monetary value of the Chapter 380 or 381 agreement in terms of an abatement. For example, the parties might structure the agreement to provide for an effective eighty percent abatement over ten years. But even though the monetary value of the agreements may be described in terms of an abatement, there are some key differences between Chapter 312 abatement agreements and Chapter 380 and 381 agreements. First, abatement agreements operate to allow the project developer to avoid paying taxes while Chapter 380 and 381 agreements almost always require that the project's annual taxes be remitted as a condition to receiving future economic development incentive payments. The retroactive nature of the incentive in Chapter 380 and 381 agreements is generally less desirable for project developers because the local government will typically hold the tax dollars for a six-to-twelve-month period before it makes the economic incentive payment to the taxpayer. The project developer foregoes the use and time value of its funds during this period.

Second, Chapter 380 and 381 agreements typically build in an "out" for the local government. The nature of Chapter 312 abatement agreements is that they are self-operative for the taxpayer—the taxpayer simply withholds payment of the abated taxes. But since Chapter 380 and 381 agreements customarily require the remittance of taxes as a condition to eligibility for incentive payments, the project developer must rely on the local government holding up its end of the bargain. Some Chapter 380 and 381 agreements will contain a provision that permits the local government to withhold the economic development payment—even when legitimately earned by the taxpayer under the terms of the agreement—if sufficient funds are not budgeted to make the payment. The taxpayer can negotiate remedies in the agreement if the local government fails to make a payment, but these remedies generally will not include specific performance. In most agreements, the remedy will be to extend the time of performance so that the taxpayer may eventually realize the full value negotiated in the agreement. Ultimately, in almost all Chapter 380 and Chapter 381 economic development agreements, there is some level of uncertainty that the city or county will fulfill its obligation to make all of the required economic development payments.

V. CONCLUSION

Energy projects and property tax incentives have historically made a successful pairing, and there is no reason to expect that this will not also be true for nuclear energy projects. For the local government, a nuclear energy project promises to bring a large amount of new taxable property into a local taxing district—with the project developer even likely becoming the largest property owner (by taxable value) in the district. From the developer's perspective, ad valorem property taxes are likely to be one of the largest annual expenses for a new nuclear project, so any opportunity to reduce property taxes is likely to act as a significant incentive when choosing a project location. As localities in Texas compete with each other and with other states for capital investment, being able to offer a valuable property tax incentive is an essential tool. The project developer's property tax counsel must be well-versed in the relevant statutes to help the client evaluate, negotiate, and enter into enforceable tax incentive agreements.

[96] Tex. Local Gov't Code §§ 380.001(a), 381.004(b), (h).

CHALLENGES AND OPPORTUNITIES WHEN ADVOCATING FOR RESPONSIBLE LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT

Brian Christian
Advocates for Responsible Disposal in Texas
Austin, Texas

Digest

Nuclear power is essential for meeting current and future demand for electricity. However, the disposal of radioactive waste has been a chokepoint in the development of nuclear power. Opponents of nuclear energy use radioactive waste management as an excuse to oppose the deployment of nuclear power that would ensure grid reliability and a safe, carbon-free source of energy. Further, busy policymakers and the general public do not have the time to drill down into the nuances of radioactive waste management, making them susceptible to conflation and misinformation about waste management.

Despite this, nuclear energy is "having a moment." Texas looks to lead the way in the deployment of Advanced Nuclear Reactors to provide dedicated power to industry and further secure the grid.

With a focus on low-level radioactive waste, this article will discuss the challenges and opportunities involved with advocating for this crucial source of energy and offer practical advice for how to frame and discuss the radioactive waste issue. It will also look downrange at upcoming policy issues that will influence the discussion in the years and decades to come.

I. Introduction

Few public policy issues are more debated than the management of radioactive waste. The cultural associations around radioactive waste, unfortunately often negative, are part of the collective consciousness. These associations, however, may obscure, rather than illuminate, the important distinctions among the various forms of radioactive waste and from where they come. Issues get conflated, impeding the efforts of lawmakers, policymakers, and the public to make well-informed decisions.

Established in 1994 to support the Low-Level Radioactive Waste Disposal Authority, Advocates for Responsible Disposal in Texas (ARDT) is an organization representing industries that use radioisotopes and the generators of a particular form, or category, of radioactive waste—*low-level radioactive waste (LLRW)*. It served as a platform to voice support at city, county, state, and federal levels for the development and construction of a LLRW disposal facility. ARDT played a major role in the public hearings on the proposed disposal facility near Sierra Blanca, Texas. ARDT is supported by Texas' two nuclear power plants—Comanche Peak Nuclear Power Plant in Glen Rose; and the South Texas Nuclear Operating Company near Bay City—as well as by the health physics, medical, and university research communities.

ARDT's overarching mission, consistent with the policy of the State of Texas, is to help LLRW generators ensure its safe and economical disposal; and reduce regulatory uncertainty. To those ends, ARDT and the generators work closely and collaboratively with the state's leadership, the Legislature, regulatory authorities, and local stakeholders. ARDT also works with Texas' licensed facility for the disposal of LLRW, operated by Waste Control Specialists (WCS), located in Andrews County. The WCS site is well-suited for the safe disposal of LLRW and is the first choice for generators in the Texas and Vermont LLRW Disposal Compact.

Why LLRW? First, it has a very clear and well-defined disposal pathway. More importantly, it, along with "very low-level radioactive waste," comprise the largest volume of radioactive waste that is generated (about 95 percent, per the International Atomic Energy Agency).

The title of this paper is *Challenges and Opportunities When Advocating for Responsible Low-Level Radioactive Waste Management*. To start, what are the challenges? A few come to mind:

- Overcoming multi-generational opposition to nuclear power and negative connotations in the media and popular culture.
- The conflation, deliberate or otherwise, of the different forms of radioactive waste and their relative risks.

And the opportunities?

- A younger generation coming up that is more pro-nuclear.
- Wide-ranging support for nuclear power.

We believe that we can overcome the challenges and take full advantage of the very real opportunities that are already manifesting; and we can do so in a way that is balanced, factual, and responsive to the audience's concerns.

Every year, we speak to a class within the Department of Nuclear Engineering at Texas A&M University—*Communicating Technical Issues to the Public*. We focus on how to talk about radioactive waste. The Student Chapter of ARDT was awarded the Richard S. Hodes Honor Lecture Award from the Southeast Compact Commission, recognizing innovations in the management of LLRRW. Additionally, we have provided testimony before Texas legislative committees and regulatory agencies. Perhaps in a departure for this publication, we are not attorneys. What we have, however, is 70+ years combined working in the public policy space, including many battles fought in the trenches of environmental policy and regulation. This experience informs our approach.

Finally, as a speaker at the inaugural Texas Nuclear Summit (held in Austin on November 18, 2024) succinctly put it, the recurring questions around nuclear energy are and will be, "Is it safe?" and "What about the waste?" We could not agree more. The waste question absolutely goes hand-in-hand with any discussion of the more widespread deployment of nuclear power generation.

II. Overcoming the Challenges by Answering Five Basic Questions

First, a quick anecdote to illustrate what not to do. Back in 1999, we attended a Texas legislative hearing on LLRW policy. The committee chairman, who never asked a question he did not already know the answer to, asked the expert witness from a regulatory agency, "What is low-level radioactive waste?" The response: "It's not high-level radioactive waste." He smiled faintly, glanced down at his notes, then looked up and replied, "Can you give us some examples?"

The response, of course, was technically correct, neutral, safe, and not all that helpful.

How you talk about radioactive waste, how it is framed and the order in which you lay it out, is vitally important to addressing the challenges noted above. We find that when discussing radioactive waste generally, and LLRW in particular, it helps to answer the following five questions in this order. This allows us to methodically move through key information. It also allows us to nip certain issues in the bud while we control the narrative, particularly the conflation of the types of radioactive waste. We also find this approach helps put the issue in real-world terms, and it provides proper scope and scale for what we are talking about. Feel free to adapt for your own talking points.

Why are radioisotopes important?

Their prevalence and wide variety of uses are not well known. Explaining that they are used in medicine, prescription drug tests, medical instrument sterilization, and disease treatment, as well as a number of industrial applications (e.g., oil and gas exploration) is helpful. This also helps to separate their beneficial uses from other connotations, such as nuclear weaponry.

What is radioactive waste?

This is crucial, because this is where the conflation, inadvertent or deliberate, often occurs. Here is another example from the real world. At several hearings at the Texas Legislature on LLRW policy and legislation, nuclear opponents would mention Chernobyl, spent fuel rods, and the Waste Isolation Pilot Plant (a deep geologic depository for defense-generated transuranic waste located in New Mexico). In that moment, busy legislators did not have the time to tease out the nuances and key differences among waste types, which led to confusion and misunderstanding.

This put us in a position of trying to clean things up. Thus, our approach is to explain that there are several different forms of radioactive waste with key differences among them. In our experience, the following are most frequently mentioned.

- *High-level radioactive waste*, which is the highly radioactive materials produced as a by-product of the reactions inside nuclear reactors. It includes spent nuclear fuel. Such waste can take hundreds to thousands of years to decay to safe levels.
- *Naturally occurring radioactive materials (NORM)*, which are radioactive elements that are naturally present in the Earth's crust. NORM is generated, for example, in oil and gas production.
- *Low-level radioactive waste,* which is a general term for a wide range of waste produced by a variety of industries, medical research and treatment facilities, labs, and nuclear power.

Because LLRW is so wide-ranging, and taking a cue from the aforementioned committee chairman, it is best to provide examples. The examples of LLRW we cite include:

- materials, such as filters, used to clean water at a nuclear power plant;
- sealed radioactive sources used in industrial and medical facilities for such diverse things as cancer treatment or oil and gas exploration and production;

- contaminated hand tools, components, piping, and other equipment from nuclear power plants and other industries;
- research equipment and animals from laboratories where radioactive materials are used;
- shoe covers, lab coats, cleaning cloths, paper towels, and other supplies used in an area where radioactive material is present; and
- containers, cloth, paper, fluids, and equipment that came in contact with radioactive materials used in hospitals to diagnose or treat disease.

This approach illustrates that LLRW comes from many productive industries and provides concrete examples of the types of materials about which we are talking. It also allows to clearly illustrate that LLRW is NOT spent fuel.

What are the classes of LLRW?

It is also helpful to differentiate among the different types of LLRW. This helps highlight the relative volumes of waste, which provides perspective and scale. The NRC classifies LLRW according to its hazard. There are four classes based on the concentrations of radioactive material:

- *Class A* contains the lowest radioactive concentration and constitutes about 91 percent of the volume of LLRW generated in the United States, but comparatively little in the way of radioactivity.
- *Classes B and C* make up the remaining 9 percent of the volume of LLRW, but are more radioactive, accounting for 75 percent of the total radioactivity of all LLRW.
- *Greater Than Class C, or GTCC, Waste*, which is more radioactive than Class C waste and must be handled differently. GTCC makes up less than one percent of the volume.

Classes A, B, and C LLRW are safely and routinely disposed of in near-surface disposal sites. Currently, there are no facilities in the United States authorized to accept GTCC LLRW for disposal. GTCC Waste is being stored at various facilities in the United States awaiting a disposal pathway, but national policy is currently in transition (the NRC is considering a federal rule that could allow for the disposal of most GTCC in near-surface land disposal).

How is LLRW disposal regulated and monitored in Texas?

Here, we emphasize that LLRW is already rigorously regulated, and that there is a clear national policy for its safe management.

Beginning in the 1980s, the United States Congress determined that the most effective way to manage LLRW among the states was through the development of cooperative agreements, called Interstate Compacts. The States of Texas, Maine, and Vermont created one such compact, though Maine later withdrew. Today, the Texas/Vermont compact is one of 10 such interstate compacts in the United States. Texas, in turn, hosts the compact's disposal facility (CWF), which is located in Andrews County, northwest of Midland and Odessa. LLRW generated from those two states can be disposed of in the CWF.

At the federal level, of course, is the NRC. At the State level, Texas is an "Agreement State," meaning the NRC has authorized Texas to license the processing and disposal of LLRW in Texas, provided the state maintains rules that are compatible with the NRC's.

The Texas Commission on Environmental Quality (TCEQ) is the Texas agency that has primary responsibility for regulating the processing and disposal of LLRW. The Texas Department of State Health Services also plays a regulatory role, overseeing the processing and storage of LLRW generated by its licensees, while the waste is located at the site where it is generated. Examples would include medical or industrial facilities.

The Texas Low-Level Radioactive Waste Disposal Compact Commission (TLLRWDCC) regulates the importation of LLRW into the Texas-Vermont Compact. Other states and Compacts can obtain permission from TLLRWDCC to import their LLRW for disposal in the CWF. The TLLRWDCC closely monitors imports to ensure adequate capacity remains for Texas and Vermont generators. The Commission also regulates exports of LLRW generated in Texas or Vermont that will not be disposed of at the Texas Compact facility. TLLRWDCC is also responsible for contingency planning in the event the Compact Waste Facility (CWF) is closed.

LLRW originating outside the United States or its territories may not be imported into the State of Texas for disposal. Waste originating in Texas may be exported to foreign countries in accordance with the rules of the NRC.

Is disposal safe?

Absolutely, for the reasons stated above and below. There are a total of four (4) operating LLRW disposal facilities in the United States—Waste Control Specialists (WCS); Energy Solutions' Barnwell LLRW disposal facility in Barnwell, South Carolina; U.S. Ecology in Richland, Washington; and Energy Solutions' disposal facility in Clive, Utah. WCS can accept all three Classes of waste from all over the country, subject to the review and approval of the TLLRWDCC. The other sites are limited either by the Class of waste they can accept and/or from where it is generated.

WCS operates the Texas-Vermont Compact Waste Facility (CWF) under a license issued by the TCEQ. That license authorizes treatment, processing, and near-surface land disposal of LLRW. WCS can accept only Class A, B, and C LLRW for disposal, though it is authorized to store a limited amount of GTCC. A vitally important point to make is that WCS license is for the *operation* of the site; the State of Texas retains ownership of the CWF. It is also helpful to point out that TCEQ maintains two resident inspectors at the site.

WCS also operates other facilities at the site. For example, they are also permitted by TCEQ to operate an industrial and hazardous waste disposal cell under the Federal Resource Conservation and Recovery Act, or RCRA. Some Class A LLRW can qualify for disposal in the RCRA facility after careful analysis by WCS. WCS also operates a "Federal Facility," for waste produced by certain agencies of the federal government and a "Byproduct Facility" for waste produced by the decommissioning of the Ohio-based Fernald Feed Materials Production Center.

Taken all together, we believe that answering these five questions in these ways helps to put LLRW in its proper context. This in turn, we believe, can go a long way toward alleviating people's concerns.

III. The Opportunities—A Reason for Hope

Nuclear energy is " having a moment." With the issuance of the report of the Texas Advanced Nuclear Reactor Working Group (November 18, 2024), Texas looks to lead the way in the deployment of Advanced Nuclear Reactors to provide dedicated power to industry and further secure the grid. The report establishes a framework for future nuclear power development and will continue the vital discussion around this issue.

However, the waste issue has not gone away. We are preparing for debates during the upcoming 89th Legislature about LLRW disposal policy, particularly as it relates to the transportation and storage of GTCC waste (and perhaps a pre-emption of future disposal).

We advise being prepared for the waste issue to be pulled into the broader discussion on nuclear policy in Texas. Indeed, the waste issue, long a chokepoint in the development of new nuclear power, could be used to try to impede progress and block legislation that would incentivize the wider deployment of nuclear power. For these reasons, this discussion about how to talk about radioactive waste could not be timelier.

There are reasons to hope, however, that the long-standing challenges around nuclear power and radioactive waste can be surmounted. Above we mentioned two opportunities that are already manifesting—the next generation of nuclear advocates, and the growing support for nuclear power.

When we made our annual presentation at Texas A&M last September, we met with two representatives from the Nuclear Advocacy Resource Organization (NARO). They are working to reach college and high school students with a positive message about nuclear power, and they sought our advice for how to address the waste issue. Honestly, we think we learned more from them. One of their leaders told us their starting point is to make sure people understand the difference between nuclear power and nuclear weapons, which is a great place to start. This removes the specter of a mushroom cloud right off the bat. Well done, NARO.

Later that same morning, when we alluded to the cultural connotations around nuclear power during our presentation, a young man raised his hand and asked, quite reasonably, "Do you think *The Simpsons* really resonates with young people anymore?" This pulled us up a little short, but we immediately conceded the point…and took it to heart.

And, at the recent Texas Nuclear Summit, a speaker pointed out that even though the workforce in the nuclear space is getting older (a separate but hugely important issue), so is the *opposition* to nuclear power. He was correct. After all, *The China Syndrome* and the *No Nukes Concert* were cultural touchstones more than *45 years ago*.

Things do feel different, and the advocacy from the generation of leaders coming up gives us hope. The stakes are high, no matter where one stands. For some, responding to climate change is paramount. For others, the key issue is electric reliability in the face of surging demand. Nuclear power can meet both of these goals and deserves support. And, as we have hopefully illustrated above, the waste issue is not some bogeyman from whom we should run away. Rather, we can meet the issue head-on and provide information that is balanced, factual, and addresses the questions and concerns of our audience.

For additional information about Advocates for Responsible Disposal in Texas, please contact Edward Selig, ARDT General Manager (eselig@ardt.org) or Brian Christian (bchristian@ardt.org).

NUCLEAR COGENERATION AS A STRATEGIC SOLUTION FOR TEXAS ENERGY

David Galeano-González, PhD
Universidad Nacional de Colombia
Medellín, Colombia
dagalean@unal.edu.co

Alejandro Garcia Herrera, MS
Sunrise Energy S.A.S.
Bogotá, Colombia
alejandro@sunriseenergy.com.co

Abstract

There is a need for new energy strategies in Texas based on extreme weather, an isolated grid, balancing fossil fuels with clean energy, high energy demand, and energy prices. It requires immediate technical and financial solutions that can be integrated into the clean energy matrix. This article presents a business perspective for using a single energy source efficiently to produce power and useful thermal energy, known as cogeneration. Nuclear cogeneration is suggested as a market entry opportunity for nuclear technology Gen III and IV of SMRs. It explores the economic, technical, and regulatory aspects of implementing nuclear cogeneration systems in Texas to respond to high energy demand from data centers. It addresses decommissioning coal plants by 2030, converting coal power plants to nuclear power plants with SMR power plants (C2N strategy), and showing a new business opportunity for using waste heat to obtain potable water through desalination and manufacturing hydrogen.

1. Introduction

Texas stands at a pivotal moment in its energy evolution, transitioning from a historical reliance on fossil fuels to a future increasingly shaped by renewable energy sources. This transformation is underscored by the state's unique energy profile: high energy consumption coupled with substantial renewable generation. While these factors present challenges, they also offer significant opportunities. In this context, integrating nuclear energy, particularly as nuclear cogeneration with Small Modular Reactors (SMRs), emerges as a unique microgrid solution to meet rising energy demands for electricity and heat, reducing carbon emissions and enhancing grid reliability.

Leading the United States in renewable energy production, Texas has leveraged initiatives like the Competitive Renewable Energy Zones (CREZ) to expand its wind and solar infrastructure [1]. Despite these advancements, fossil fuels dominate the state's energy mix, contributing significantly to its carbon footprint [2]. Research into hybrid solar-wind plants demonstrates the potential for large-scale implementation, particularly in agricultural regions like South Texas, though high initial investment costs remain a barrier [3]. The intermittency of renewable energy sources, particularly wind and solar, poses significant challenges to grid stability, especially during peak industrial demand [2]. Various strategies, including advanced techniques like dynamic time warping and k-means clustering, have been proposed to optimize electric vehicle (EV) charging patterns and improve renewable integration [4]. However, these solutions alone may not address the state's growing energy demands.

Nuclear cogeneration, particularly with SMRs, offers a reliable source of low-carbon baseload power that complements the variability of renewables, improving overall grid stability and powering water desalination plants. Also, SMRs can provide industrial heat for the petrochemical and manufacturing sectors. Unlike traditional large-scale nuclear plants, SMRs offer a more flexible and cost-effective option, aligning with Texas' need for scalable, sustainable energy solutions by deploying decentralized, modular configurations. This makes them a critical component of the state's strategy to meet increasing electricity demand while reducing carbon emissions and supplying the cleanest energy source for hydrogen fabrication.

Despite progress in renewable energy, Texas faces political and economic barriers to fully decarbonizing its energy system and its industrial process. The state's conservative energy policies and historic reliance on fossil fuels complicate efforts to accelerate the transition [2]. Nevertheless, strategic investments in nuclear cogeneration and renewable technologies could position Texas as a leader in sustainable energy innovation, balancing economic growth with environmental stewardship and significant job creation.

This paper presents technical, economic, and regulatory frameworks necessary for successfully integrating nuclear cogeneration in Texas. For example, a 300 MW SMR could produce enough electricity to power

~230,000 homes while desalinating up to 250,000 cubic meters of water per day. SMR's capabilities can reshape the state's energy landscape and ensure long-term sustainability.

2. Background and Literature Review

Texas has one of the most diverse energy portfolios in the United States, with contributions from fossil fuels at 54%, renewable sources at 35%, nuclear power at 10%, and 1% others, approx. [29] , [30], [31] [32] [33]. It is at a critical juncture in striving to reduce carbon its energy systems while maintaining grid stability and energy security. Historically, the state has been a leader in energy production, excelling in the oil and gas, and wind sectors. In 2022, Texas produced over 1.83 billion barrels of crude oil and 11.2 trillion cubic feet of natural gas, solidifying its position as a major player in global energy markets [5]. Simultaneously, Texas leads the nation in wind energy generation, producing 93 TWh of electricity from wind in 2020. However, integrating these renewable energy sources into the state's isolated grid presents challenges, particularly during extreme weather events that exacerbate supply-demand imbalances, such as in February 2021 with Winter Storm Uri [2]. Moreover, the continued reliance on fossil fuels contributes significantly to carbon emissions, underscoring the need for innovative solutions to achieve ambitious net-zero goals.

Nuclear Cogeneration, particularly with SMRs, provides a viable pathway to address these challenges. Nuclear power offers a reliable and carbon-free baseload energy source, which complements the intermittency of renewables like wind and solar. SMRs, with their scalable and flexible designs, are particularly well-suited for integration into existing infrastructure. They represent a promising option for replacing aging coal plants slated for decommissioning under Texas' 2030 plans [6]. Cogeneration with SMRs produces electricity and thermal energy, improving overall energy efficiency. This dual capability aligns well with Texas' energy-intensive industries, including rapidly expanding data centers, which demand consistent and reliable power and cover thermal needs for petrochemical, mining, and manufacturing industries.

The economic and environmental benefits of nuclear cogeneration are substantial. Utilizing nuclear energy in industrial processes such as ammonia production can reduce CO_2 emissions by up to 95% compared to conventional methods [7]. Moreover, the high energy density of nuclear fuel minimizes land and resource use, making it an efficient solution for large-scale power generation. SMRs enhance cost efficiency through modular designs that reduce capital expenditures and enable faster deployment than traditional reactors [8]. Beyond clean electricity, nuclear cogeneration systems can support hydrogen production, diversifying Texas' energy portfolio and bolstering its position in the emerging hydrogen economy. Also, SMRs can address water scarcity issues with sustainable desalination for a rapid population growth that increases demand for fresh water. However, the integration of nuclear cogeneration in Texas faces notable regulatory and technical hurdles. While critical for public trust, strict safety and environmental regulations often prolong project timelines and increase costs. Lessons from international case studies, such as Spain's renewable energy sector, demonstrate how policy frameworks significantly influence the economic viability of energy projects [9]. For Texas, aligning nuclear energy deployment with its existing market structures will require carefully navigating these regulatory barriers. Additionally, advancements in nuclear technology are essential to address ongoing concerns surrounding waste management, safety, and public perception [10]. Unlike traditional nuclear plants, SMRs are designed to shut down safely and restart quickly, making them suitable for managing grid fluctuations. Microgrids have become more relevant, giving overall grid resilience. [34].

Public acceptance remains a significant barrier to nuclear energy adoption. Despite the safety and efficiency improvements offered by modern technologies such as SMRs and high-temperature reactors, overcoming skepticism will require transparent communication about advancements and rigorous safety standards. Addressing concerns about radioactive waste and demonstrating nuclear cogeneration's economic and environmental benefits are key to gaining public support. Ultimately, increasing acceptance of nuclear energy in Texas will be up to its ability to complement renewable energy's output, and advanced SMR will help with their closed fuel cycle, reducing the risk of waste significantly and setting up long-term sustainability goals.

3. Nuclear Cogeneration Business Model

The total potential market size annually is electricity: $4–6 billion, Industrial Heat: $3–6 billion annually, Desalination: $1–2 billion annually, Hydrogen: $1–2 billion annually, Grid Resilience: $0.5–1 billion. And Total Addressable Market (TAM): $10–17 billion annually. [35], [36], [37], [38]. [39],[40],[41], [42].

The factors driving market growth are population growth, where Texas is projected to grow by 10 million people by 2050, and increasing energy and water demands. Industrial Expansion: Texas is home to 30% of U.S. refining capacity and growing petrochemical industries, as well as policy and sustainability goals, with emissions reduction targets that could drive interest in nuclear as a zero-carbon solution.

Nuclear cogeneration with SMRs emerges as a transformative opportunity to meet diverse challenges. This business can address critical issues like grid stability, water scarcity, and carbon emissions. Introducing a business model that requires a strategic approach that combines cutting-edge technology, financial innovation, regulatory compliance, and public engagement, evaluating the feasibility and profitability of its implementation in Texas. It integrates technical, financial, and market parameters to quantify the economic outcomes of a cogeneration system that produces electricity and thermal energy. The primary objective is to assess the financial viability of deploying SMRs in Texas's current energy landscape, considering the state's regulatory, market, and infrastructural conditions and explaining how to mitigate investment risk by applying PPAs and EaaS agreements.

The value proposition of investing in a nuclear cogeneration project includes: **Dual Output Benefits**: Electricity + industrial heat, desalinated water, or hydrogen production. **Reliability**: 24/7 operation independent of weather, stabilizing intermittent renewable energy sources. **Sustainability**: Carbon-free energy supporting climate goals. **Cost Savings for Partners**: Long-term, stable energy costs compared to volatile natural gas prices. **Modularity**: is a key advantage that enhances scalability, flexibility, and adaptability to diverse energy and industrial needs.

Six modular SMR designs based on Gen IV technologies go from 10 MWe to 300 MWe and temperatures from 450 C to 950 C. It allows them to be tailored for specific cogeneration applications, such as powering industries, producing hydrogen, or addressing water scarcity through desalination. [43], [44], [45], [46].

This business model is based mainly on a 300 MW SMR operating at a capacity factor of 0.95, resulting in an annual electricity production of approximately 2.5 million MWh. This reflects the reliability and efficiency of modern SMR technology. The initial capital cost is estimated at $500 million, with annual Operation and Maintenance (O&M) costs set at 5% of capital expenditure. Fuel costs are assumed to be $10 per MWh of electricity generated, based on current uranium market prices and fuel cycle efficiency [11].
Projected revenue streams are based on market prices of $50 per MWh for electricity and $30 per MWh for thermal energy [12]. The system allocates 30% of electricity output to thermal energy production, enabling industrial processes, district heating, and water desalination applications. These revenue streams reflect Texas' diverse energy market.

Financial metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), and Levelized Cost of Energy (LCOE) are calculated over a 60-year operational period using a discount rate of 8% and a corporate tax rate of 21% [13]. The results yield an NPV of $627.82 million and an IRR of 17.3%, demonstrating the financial attractiveness of the project under baseline assumptions. The payback period is estimated at six years, highlighting a rapid recovery of the initial investment.

A graphical representation of annual cash flows (Figure 1) highlights the initial investment burden in year 0, followed by consistent positive cash flows from year 2 onward. Tax benefits derived from depreciation during the first 20 years significantly enhance the project's financial performance in the early stages.

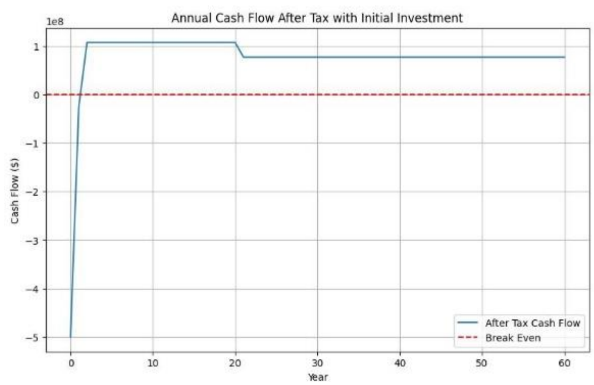


Figure 1: Annual Cash Flow After Tax with Depreciation

3.1 Revenue and Cost Analysis

The economic model includes a detailed evaluation of annual revenues and costs associated with implementing a 300 MW SMR for nuclear cogeneration in Texas. As illustrated in Figure 2, the project achieves stable yearly revenues exceeding $145 million from year one onward. These revenues are derived from electricity sales ($50/MWh) and thermal energy sales ($30/MWh), considering a total annual production of 2.5 million MWh of electricity, with 30% allocated for thermal energy production.

O&M costs remain constant at approximately $25 million annually, calculated as 5% of the initial capital expenditure. Fuel costs, estimated at $10 per MWh, are stable at around $25 million annually. These predictable cost structures contribute to consistent cash flows, ensuring the project's financial stability throughout its operational lifetime.

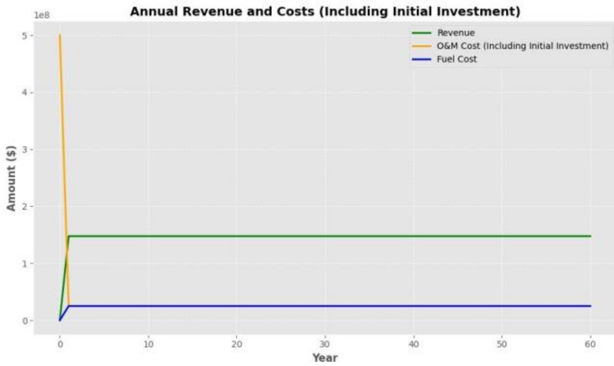


Figure 2: Annual Revenue and Cost Breakdown

The substantial gap between revenue and costs underscores the economic viability of SMRs for nuclear cogeneration. The tax savings from depreciation further enhance cash flows during the first 20 years, as shown in the annual and cumulative cash flow analysis (Figure 1).

3.2 Monte Carlo Simulation

A Monte Carlo simulation was conducted to Monte Carlo simulation was conducted to assess the resilience of the 300 MW SMR cogeneration project under uncertain scenarios. This probabilistic analysis evaluates the impact of variations in key parameters, including electricity prices, fuel costs, and O&M rates.

Simulation Parameters: The simulation used the following ranges for input variables:

- Electricity Prices: Uniformly distributed between \$45/MWh and \$55/MWh.
- Fuel Costs: Uniformly distributed between \$9/MWh and \$11/MWh.
- O&M Rates: Uniformly distributed between 4.5% and 5.5% of the initial CAPEX.

One thousand iterations were performed, generating annual cash flows over the 60-year project lifetime. NPV and IRR were calculated using an 8% discount rate for each scenario.

Statistical Results: The Monte Carlo simulation results are summarized in Figures 3 and 4. The mean NPV across all scenarios was \$452.81 million, with a standard deviation of \$74.04 million, indicating a high likelihood of achieving positive returns. The mean IRR was 15.39%, with minimal variability, suggesting consistent profitability across scenarios.

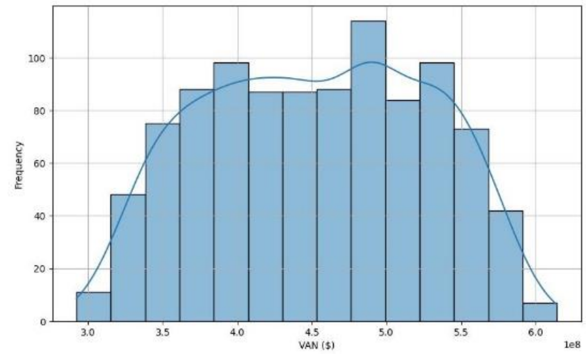


Figure 3: Distribution of NPV from Monte Carlo Simulation

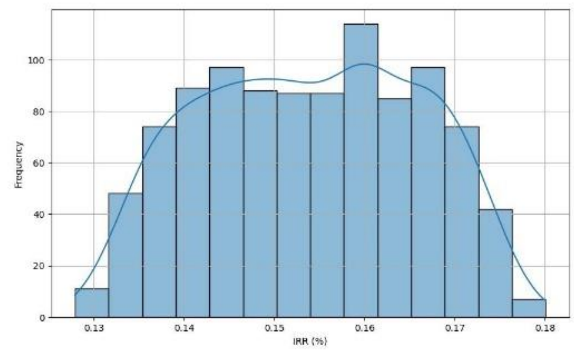


Figure 4: Distribution of IRR from Monte Carlo Simulation

Discussion: The Monte Carlo analysis confirms the project's financial resilience under various market conditions. Electricity prices had the most significant impact on outcomes, but even unfavorable scenarios yielded positive NPVs, underscoring the robustness of SMR technology for cogeneration applications.

3.3 Investment Risk Control with PPA and EaaS

Nuclear cogeneration providers can reduce financial, operational, and market risks, facilitating investment in Texas by leveraging PPAs and EaaS models. These mechanisms align well with Texas' competitive energy market, offering scalable and flexible solutions to meet industrial, municipal, and residential needs. A power Purchase Agreement (PPA) is a long-term contract (typically 10–40 years) between the nuclear cogeneration provider and the buyer to reduce market price volatility risks, especially in Texas' deregulated ERCOT market, where electricity prices fluctuate widely. Also, it secures funding for initial capital investments by providing a bankable, steady income source. An industrial facility in Texas could sign a 20+ ----year PPA for high-temperature process heat and electricity from an SMR cogeneration plant, reducing cost and increasing efficiency, without the risk of inventing directly on a nuclear cogeneration plant.

Energy-as-a-Service (EaaS) is a business model where energy solutions are provided as a service to customers rather than requiring them to invest, install, or maintain energy systems themselves. Customers only pay for the energy or related services they use on a subscription or pay-per-use basis, including data analytics to improve efficiency. The nuclear cogeneration provider holds ownership of the SMR, and the customer pays for the energy as a service consumed.

Many successful case studies of these types of agreements exist in the US and Texas. Vogtle Nuclear Plant PPA (Georgia, USA), Ørsted Offshore Wind PPAs (Global, incl. the U.S.), Texas Solar and Wind PPAs (ERCOT Market), Ameresco's EaaS Projects (USA), Veolia's EaaS for District Energy (Global), ExxonMobil Carbon Capture EaaS (Houston, Texas).

4. Policy Recommendations

The successful deployment of SMRs for nuclear cogeneration in Texas requires a robust and adaptive policy framework. Regulatory and market structures must align to support the integration of nuclear energy within the existing energy ecosystem while addressing key economic and social challenges. This section outlines specific policy recommendations to facilitate the adoption of nuclear cogeneration and its alignment with Texas' energy goals.

Regulatory approval remains one of the most significant barriers to deploying SMRs for nuclear cogeneration, particularly in regions like Texas, where energy markets and the complex regulatory environment are uniquely structured. While rigorous safety and compliance standards are essential to uphold public trust and operational security, the current regulatory framework often results in lengthy permitting processes, overlapping jurisdictional requirements, and increased financial burdens on developers. Addressing these challenges is critical to accelerating the deployment of SMRs and leveraging their potential to transform Texas' energy landscape.

One of the key opportunities to streamline regulatory processes lies in tailoring the framework to the specific characteristics of SMRs. These reactors fundamentally differ from traditional large-scale nuclear plants due to their smaller size, modular construction, and enhanced safety features. Passive safety systems, smaller reactor cores, and lower operational risks substantially reduce the likelihood of severe incidents, making SMRs inherently safer [14]. The Nuclear Regulatory Commission (NRC) should adopt risk-informed and performance-based approaches that prioritize oversight of areas with the highest safety significance while reducing redundancy in administrative reviews. This strategy could significantly decrease the time required for licensing without compromising safety.

Standardized reactor designs offer another pathway to expedite regulatory approval. By pre-certifying SMR designs that meet rigorous safety and performance criteria, regulatory agencies can minimize the need for case-by-case evaluations during the project approval phase. Such an approach would reduce the administrative burden and provide developers with greater certainty regarding project timelines and costs [15]. Pre-certified designs also facilitate broader market adoption by creating a streamlined pathway for future deployments.

Harmonization between federal and state regulations is essential to address the fragmented oversight that often characterizes nuclear projects in the United States. The overlapping responsibilities of federal entities like the NRC and state agencies can create confusion and inefficiencies. Establishing collaborative frameworks, such as Memorandums of Understanding (MOUs) between these bodies, can delineate clear roles and responsibilities, ensuring a more cohesive regulatory process. For example, in Texas, aligning NRC oversight with state-specific market structures under the Electric Reliability Council of Texas (ERCOT) could lead to tailored regulations that better reflect local energy needs and infrastructure realities [16].

Adopting international best practices can provide valuable insights for streamlining regulatory processes. Organizations such as the International Atomic Energy Agency (IAEA) and the OECD Nuclear Energy Agency (NEA) have developed comprehensive frameworks for SMR deployment that emphasize efficient licensing procedures while maintaining safety standards [17]. Bilateral collaborations with countries successfully deploying SMRs, like Canada and Finland could further inform U.S. regulatory reforms. For instance, Canada's approach to pre-licensing vendor design reviews has significantly reduced project timelines, providing a model that the NRC could adapt to the U.S. context.

The use of advanced digital tools offers another promising avenue for regulatory optimization. Digital platforms for document submission, automated compliance checks, and real-time tracking of project milestones can improve transparency and reduce delays. Furthermore, digital twins—virtual replicas of physical SMRs—enable regulators to simulate operational scenarios, identify potential risks, and validate safety measures before physical construction begins. These tools enhance the efficiency of the regulatory process and provide a higher level of confidence in the safety and reliability of new installations.

Public perception and stakeholder engagement are also critical components of regulatory reform. Transparent communication about the regulatory process and the unique safety features of SMRs can help address public concerns and build trust. Educational campaigns, or DOE programs like reaching communities [47] to highlight nuclear energy's environmental and economic benefits, coupled with open forums for community feedback, can foster broader acceptance. Additionally, creating publicly accessible databases that track regulatory progress and project milestones can enhance accountability and ensure stakeholders remain informed throughout the process [18].

5. Strategies for Promoting Nuclear Cogeneration Investments

The successful deployment of SMRs for nuclear cogeneration in Texas requires a comprehensive strategy to overcome financial, operational, and market-related challenges. High initial capital costs, long development timelines, and the competitive nature of Texas' energy market demand innovative approaches to incentivize investment and ensure seamless integration of nuclear energy into the state's energy portfolio. This section outlines strategies centered on financial incentives, collaborative partnerships, and market-based adjustments to support the adoption of atomic cogeneration.

Financial incentives have historically played a pivotal role in accelerating the adoption of emerging energy technologies. Extending mechanisms such as tax credits, loan guarantees, and production subsidies to SMRs could significantly reduce their financial barriers. For instance, a nuclear-specific adaptation of the Renewable Energy Production Tax Credit (PTC) could provide a per-megawatt-hour credit for electricity generated by SMRs, directly lowering operating costs during early deployment phases [19]. Similarly, loan guarantees offered by federal programs like the Department of Energy's (DOE) Loan Guarantee Program can reduce financial risks for developers by providing access to capital at lower interest rates [20]. These tools lower the economic hurdles for investors and align nuclear energy with policies traditionally reserved for renewables, fostering a more balanced and sustainable energy mix.

Public-private partnerships (PPPs) provide another critical avenue for advancing nuclear cogeneration projects. By pooling resources from the public and private sectors, PPPs can facilitate the development of SMRs while distributing financial risks and leveraging private sector expertise. Successful examples, such as the expansion of the Vogtle Electric Generating Plant in Georgia, demonstrate how collaborative frameworks can address the high upfront costs of nuclear projects while ensuring public accountability [21]. In Texas, such partnerships could involve local utilities, private investors, and governmental bodies working collectively to fund and operationalize SMRs. Additionally, PPPs could enable innovative cost-sharing mechanisms, such as government-backed infrastructure funds or performance-based incentives, to reduce the financial burden on private developers.

Integrating nuclear cogeneration into Texas' competitive energy market requires market design and pricing structure adjustments. The unique structure of the Electric Reliability Council of Texas (ERCOT) market, which prioritizes low-cost energy dispatch without capacity payments, presents both challenges and opportunities for SMRs. Mechanisms to value nuclear energy's reliability and low-carbon attributes, such as capacity markets or carbon pricing, could provide a stable revenue stream for SMRs, enhancing their economic viability [22]. Capacity markets, where generators are compensated for maintaining reserve capacity, would reward the baseload reliability that SMRs bring to the grid. Similarly, introducing a carbon pricing mechanism would incentivize low-emission energy sources like nuclear while internalizing the environmental costs of fossil fuels.

Market-based strategies must also consider long-term power purchase agreements (PPAs), which offer fixed-price contracts for energy over extended periods. PPAs have been widely used in renewable energy markets to stabilize revenues and reduce exposure to market volatility. Applying similar models, such as Energy as a Service (EaaS), to nuclear cogeneration projects could provide the financial predictability needed to attract investors. Furthermore, aligning nuclear projects with industrial partners through cogeneration agreements—where excess thermal energy is used for industrial processes, district heating, water desalination, or hydrogen production—could create additional revenue streams and increase the overall efficiency of SMR deployments [23].

These strategies must also address public perception, which remains a critical factor in nuclear energy adoption. Clear and transparent communication about nuclear cogeneration's economic, environmental, and social benefits is essential to gaining public trust. Educational campaigns and community engagement initiatives should emphasize the advanced safety features of SMRs, their potential to reduce greenhouse gas emissions and their role in strengthening Texas' energy independence. Public acceptance can further be bolstered by showcasing nuclear energy as a complement to renewable energy rather than a competitor, fostering a narrative of collaboration rather than conflict [24].

The combination of financial incentives, collaborative frameworks, market reforms, and public engagement strategies forms a comprehensive approach to advancing nuclear cogeneration in Texas. Addressing the economic and social barriers to SMR deployment, these initiatives pave the way for nuclear energy to play a central role in the state's transition to a sustainable and resilient energy future.

Also last but not least, job creation can play a vital role in supporting the adoption of nuclear cogeneration in Texas by addressing economic, political, and workforce-related challenges. Nuclear cogeneration projects, especially those involving Small Modular Reactors (SMRs), require significant construction, operation, and maintenance investment. This leads to the creation of high-paying, stable jobs.

SMR deployment will require highly skilled workforce jobs in engineering, manufacturing, construction, and operations. For instance, a 300 MW SMR project can generate 1,500–2,000 temporary construction jobs during development and 200–500 long-term operational jobs. Indirect Jobs will come from support industries such as supply chain, transportation, and service sectors. Studies suggest that 1.5–2 indirect jobs are created in the surrounding community for every direct nuclear job. As a result, Texas will have new economic growth, and community support for job creation can build support for nuclear projects, especially in rural or economically disadvantaged areas.

For example, Texas's strong military presence can be leveraged by retraining veterans for nuclear energy roles, given their technical skills and safety experience. Jobs are a powerful tool for gaining political and public support for nuclear projects, particularly in regions where the economy relies on fossil fuels.

6. Environmental, Technological, and Comparative Analysis of Nuclear Cogeneration

The deployment of SMRs for nuclear cogeneration in Texas presents economic and regulatory opportunities, critical environmental and social considerations, technological challenges, and insights from international case studies. This section integrates these dimensions, offering a holistic view of the factors influencing the viability and acceptance of SMRs in Texas.

From an environmental perspective, nuclear cogeneration offers substantial advantages over traditional fossil fuel-based systems and even renewable energy sources in certain aspects. SMRs provide a low-carbon alternative capable of reducing CO2 emissions by up to 90% compared to coal-fired power plants [25]. Unlike wind and solar energy, which require extensive land use, nuclear energy's high energy density minimizes its physical footprint, making it particularly advantageous for regions with limited available land or high urban density. Additionally, the cogeneration capability of SMRs enhances resource efficiency by utilizing waste heat for industrial processes, district heating, or desalination, further contributing to environmental sustainability [26]. However, public concerns surrounding radioactive waste management remain a significant barrier to acceptance. Addressing this requires clear communication about advanced waste management strategies, such as closed fuel cycles and deep geological repositories, which have been proven to isolate nuclear waste over long periods [27] safely.

Social acceptance is another critical factor in the successful deployment of SMRs. Historical incidents often shape public perception of nuclear energy despite reactor safety and waste management advancements. Transparent engagement with communities and educational campaigns emphasizing the safety features and environmental benefits of SMRs are essential to build trust and address misconceptions [28]. Moreover, highlighting the potential economic benefits, such as job creation and local investment opportunities during the construction and operation phases, can further strengthen public support.

Technologically, transitioning from coal to nuclear cogeneration (C2N strategy) poses opportunities and challenges. SMRs are inherently well-suited for such conversions due to their modular designs and ability to integrate with existing infrastructure. However, retrofitting coal power plants to accommodate SMRs requires significant upgrades to cooling systems, safety protocols, and control systems. Additionally, ensuring a robust and reliable supply chain for nuclear fuel is critical. While the global uranium market is currently stable, any disruption could impact the operational efficiency of SMRs. Addressing these challenges requires strategic planning, including investments in infrastructure, workforce training, and establishing regional fuel fabrication facilities to reduce dependence on international supply chains.

Insights from international case studies reinforce the viability of SMRs and provide valuable lessons for their implementation in Texas. Canada, for example, has demonstrated the effectiveness of streamlined regulatory processes through its pre-licensing vendor design review system, significantly reducing approval times for SMR projects. On the other hand, Finland offers a model for public engagement and waste management, having successfully implemented community-supported deep geological repositories for radioactive waste. These examples highlight the importance of adapting global best practices to local contexts, ensuring that Texas benefits from proven strategies while addressing its unique regulatory and market conditions.

By integrating environmental, technological, and comparative analyses, this discussion underscores nuclear cogeneration's multidimensional benefits and challenges. SMRs offer a pathway to decarbonize Texas' energy landscape and provide a platform for innovation and global leadership in sustainable energy systems. Addressing the difficulties outlined through targeted strategies will be essential to unlocking the full potential of nuclear cogeneration in Texas.

7. Conclusions and Recommendations

The findings of this paper highlight the transformative potential of SMRs for nuclear cogeneration as a critical component in Texas' energy makeup. SMRs offer a robust solution to the state's growing energy and water demands, decarbonization goals, and industrial expansion by providing reliable, low-carbon baseload power and valuable thermal energy for diverse applications. By addressing their deployment's technical, economic, regulatory, and social dimensions, SMRs emerge as a viable and sustainable option for reshaping Texas' energy landscape.

7.1 Conclusions

- Economic Viability: The economic analysis confirms the financial attractiveness of SMR cogeneration projects. With a projected NPV of $627.82 mil-
  lion, an IRR of 17.3%, and a payback period of six years, SMRs demonstrate strong potential for profitability under baseline conditions. Monte Carlo simulations further validate their resilience to market variability, underscoring their robustness as an investment.
- Environmental Benefits: SMRs contribute significantly to decarbonization, reducing CO_2 emissions by up to 90% compared to coal plants. Their high energy density minimizes land use, and their dual-use capability maximizes resource efficiency through cogeneration applications like desalination and hydrogen production.
- Regulatory and Market Challenges: The successful deployment of SMRs hinges on overcoming regulatory hurdles, such as lengthy approval processes and fragmented oversight. Aligning federal and state regulations and adopting international best practices can streamline these processes and reduce deployment timelines.
- Public Perception: Gaining public and political acceptance is critical. Job creation, open and honest communication, education campaigns, and stakeholder engagement must address safety and waste management concerns while emphasizing the economic and environmental benefits of nuclear energy.
- Technological Feasibility: The C2N strategy highlights the feasibility of retrofitting coal power plants with SMRs, though challenges related to infrastructure upgrades and supply chain stability require strategic planning and investment.
- Comparative Insights: Lessons from Canada and Finland reinforce the importance of streamlined regulatory frameworks, effective waste management strategies, and proactive community engagement, which can be adapted to Texas' unique context.

7.2 Recommendations

- Policy and Regulatory Frameworks:
  - Streamline regulatory processes by adopting risk-informed, performance-based approaches tailored to SMR technology.
  - Implement pre-certification of standardized SMR designs to reduce administrative redundancy and approval timelines.
  - Establish collaborative frameworks between the Nuclear Regulatory Commission (NRC) and state agencies, such as the Electric Reliability Council of Texas (ERCOT), to align market structures with nuclear integration.
- Financial Incentives and Market Mechanisms: – Extend renewable energy incentives like tax credits and loan guarantees to nuclear projects to lower economic barriers.
  - Introduce capacity markets and carbon pricing mechanisms to value the reliability and low-carbon attributes of SMRs.
  - Encourage long-term power purchase agreements (PPAs) to stabilize revenue streams and attract investors, as well as the Energy as a Service agreement.
- Public Engagement and Education:
  - Develop transparent communication strategies highlighting SMR safety advancements, economic benefits, and environmental contributions.
  - Foster public trust through educational campaigns and participatory decision-making processes that involve local communities.

- Create nuclear job opportunities in the supply chain to gain political and public support.
- Support entrepreneurship in increasing the value chain offer of nuclear cogeneration projects.
- Technological and Infrastructure Investments:
  - Invest in retrofitting existing coal plants with SMR-compatible infrastructure to leverage the C2N strategy.
  - Establish regional supply chains for uranium fuel fabrication to reduce dependence on international markets and enhance operational stability.
  - Develop local project management skills to support construction and commissioning efficiency.
- Collaboration and Knowledge Sharing:
  - Leverage international best practices by collaborating with countries experienced in SMR deployments, such as Canada and Finland.
  - Participate in global initiatives like the International Atomic Energy Agency (IAEA) and the OECD Nuclear Energy Agency (NEA) to adopt proven regulatory and operational strategies.
- Industrial Integration:
  - Align SMR projects with energy-intensive industries in Texas, such as data centers, mining, and petrochemical plants, to capitalize on cogeneration opportunities.
  - Promote nuclear cogeneration with SMR to generate electricity thermal energy for water desalination and hydrogen production, diversifying the state's energy and water portfolio.

By addressing these recommendations, Texas can position itself as a leader in sustainable energy innovation, leveraging the unique capabilities of SMRs to achieve a resilient, low-carbon energy future. Integrating nuclear cogeneration into the state's energy mix provides a pathway to decarbonization and fosters economic growth, industrial competitiveness, and environmental stewardship. This comprehensive approach ensures that Texas meets its energy and water demands while transitioning to a sustainable and secure energy landscape.

References

1. J. Cohn, "Large-scale renewables and infrastructure gatekeepers: How local actors shaped the Texas competitive renewable energy zones (CREZ) initiative," 2022.
2. D. Spence, "Texas," 2024.
3. J. Giuffrida, M. J. de la Cruz, E. Martinez-Gomez, S. Ludtke, and H. Li, "Economic feasibility analysis of developing large-scale hybrid solar-wind energy plants on farms and ranches in south Texas," 2023.
4. M. Mohammadi and J. Thornburg, "Strategizing EV charging and renewable integration in Texas," https://arxiv.org pdf/2310.17056, 2023.
5. B. Wright, "Geothermal potential runs hot in Texas," *Journal of Petroleum Technology*, 2023.
6. S. Soloviev, D. G. Zaryugin, S. G. Kalyakin, and S. T. Leskin, "Identifying the key development areas for small modular reactors," 2021.
7. R. Saeed, E. Worsham, N. Popli, J. Toman, B.-H. Choi, F. Joseck, Costanza, and D. Mikkelson, "Outlook on industrial requirements for incorporating nuclear energy into industrial processes," 2023.
8. L. Xu, "Economic analysis of nuclear cogeneration system based on high-temperature gas-cooled reactor," 2022.
9. S. Coronas, "Aportació a l'anàlisi i gestió tècnica-econòmica dels sistemes de generació distribuïda amb energies renovables i microxarxes. Introducció a la presa de decisions en el context normatiu actual," 2023.
10. J. Krumins and M. Klavins, "Investigating the potential of nuclear energy in achieving a carbon-free energy future," Energies 2023.
11. C. Pannier and R. Skoda, "Assessment of small modular reactor fuel cost," 2010.
12. S.B. Cho, A. Epiney, P. Talbot, T. Allen, and X. Sun, "Analysis of costs, benefits, and implications of pathways in capturing the value of nuclear energy: a case study of Texas."
13. A. Asuega, B. J. Limb, and J. C. Quinn, "Technoeconomic analysis of advanced small modular nuclear reactors," *Applied Energy*, 2023.
14. E. M. Hussein, "Generation modular reactors: A framework," *Nuclear Engineering and Design*, 2024.
15. T. Freyman and K. V. Kirkland, "A consequence informed licensing path selection for the design of physical protection systems at commercial nuclear power facilities," *Nuclear Science and Engineering*, 2024.
16. A. U. o'g'li Nishonov, "Nuclear governance assessing effectiveness and enhancing international cooperation," *Indonesian Journal of Innovation Studies*, 2024.
17. T. Singh, "Good regulatory practices and its evolving relevance in conformity assessment," 2023.
18. P. Davidson, M. Gerardo, F. Romero, A. Blazey, J. Villarreal, M. Beltran, C. Emilsson, F. González-Zapata, O. Kirac, S. Y. Park, A. R. Perez, D. Gerson,

M. Lafuente, S. Bautista, E. Desplanques, R. G. Arana, D. Solano, S. Schineller, and J. Gomila, "Stakeholder engagement for regulation," 2024.
19. M. Ali, A. Samour, S. Soomro, W. Khalid, and T. Tursoy, "A step towards a sustainable environment in top-10 nuclear energy consumer countries: The role of financial globalization and nuclear energy," *Nuclear Engineering and Technology*, 2024.
20. S. Yüksel, H. Dinçer, Çağatay Çağlayan, and G. S. Uluer, "Determining the optimal financial strategies for nuclear energy companies," 2020.
21. S. Krahn and A. Sowder, "Public-private partnering in nuclear reactor development - historical review and implications for today," *Journal of Nuclear Engineering and Radiation Science*, 2023.
22. A. O. Grotle, S. Dyrkolbotn, M. N. Hjelmeland, J. K. Nøland, and M. Korpas, "Economic prospects of flexible nuclear energy operation under different market conditions," 2024.
23. "Nuclear energy system modeling application package: functional overview and examples," *Nuclear Energy and Technology*, 2022.
24. H. Lin, "Affecting factors and aspects of developing nuclear public acceptance strategies," 2022.
25. J. A. M. Porto, L. de Jesus Alves, F. C. Nunes, E. Gross, H. H. S. Medrado, J. Rocha, M. M. Viana, A. P. C. Teixeira, and M. N. V. Prasad, "Nuclear energy and its role in decarbonization: Scenarios and perspectives," 2023.
26. O. Awogbemi, A. A. Adediran, R. L. Elewa, K. A. Bello, R. A. Ibikunle, F. O. Borokinni, S. Adedayo, and P. Ikubanni, "Exploring nuclear energy to meet sustainable development goals," 2024.
27. S. Yüksel, H. Dinçer, and D. Yavuz, "Effective radioactive waste management strategies in nuclear energy investments for environmental sustainability," 2024.
28. M. Hlavecek, I. Cabelkova, K. Pawlak, and L. Smutka, "Nuclear reactor at home? Public acceptance of small nuclear reactors in the neighborhood," *Frontiers in Energy Research*, 2023.
29. https://www.eia.gov/state/?sid=TX
30. http://www.ercot.com/
31. https://comptroller.texas.gov
32. https://www.texastribune.org
33. https://cleanpower.org
34. https://www.ornl.gov)
35. ERCOT Demand and Energy Reports
36. EIA Texas Energy Profile
37. https://www.energy.gov/
38. World Nuclear Association Industrial Heat
39. TWDB Water Reports
40. DOE Hydrogen and Fuel Cell Technologies Office
41. https://www.oecd-nea.org/
42. INL Advanced Reactor Reports).
43. https://www.gen-4.org/
44. https://www.iaea.org
45. https://www.energy.gov/ne
46. https://world-nuclear.org.
47. https://www.energy.gov/eere/solar/connected-communities-funding-program