LSU Journal of Energy Law and Resources

Volume 10
Issue 2 *Summer 2022*

8-11-2022

Honey, I Shrunk the Reactor: A Comment on the Journey of Small Modular Reactors Through the Nuclear Regulatory Process

Gage M. Stewart

Repository Citation
Gage M. Stewart, *Honey, I Shrunk the Reactor: A Comment on the Journey of Small Modular Reactors Through the Nuclear Regulatory Process*, 10 LSU J. of Energy L. & Resources (2022)
Available at: https://digitalcommons.law.lsu.edu/jelr/vol10/iss2/14

Honey, I Shrunk the Reactor: A Comment on the Journey of Small Modular Reactors Through the Nuclear Regulatory Process

Gage M. Stewart[*]

TABLE OF CONTENTS

INTRODUCTION

Just like flip phones and disco before it, nuclear power production in the United States ("U.S.") has all but died. Nuclear power plants situated across the nation are being decommissioned as a result of an aging nuclear fleet and an over-competitive energy market.[1] To the casual observer, the days of pursuing the "Abundant Power [of the] Atom" may appear to be

---

[*] J.D./D.C.L., 2022, Paul M. Hebert Law Center, Louisiana State University. The author extends his thanks to Professor Edward Richards and Professor Grace Barry for their guidance, support, and encouragement and to the Journal of Energy Law and Resources Volume IX and X board members.

[1] Denis Iurchak, *200 – 400 Nuclear Reactors to be Decommissioned by 2040*, ENERGYPOST.EU (Feb. 11, 2020), https://energypost.eu/200-400-nuclear-reactors-to-be-decommissioned-by-2040/ [https://perma.cc/AX7S-H3L9].

long gone.[2] In reality, however, the practical use of nuclear energy is only just emerging on the horizon with the promising development of small modular reactor ("SMR") technology.[3] This technology is a fraction of the size of current reactors and is small enough to be manufactured in factories. SMRs are also much safer and more versatile than previous reactor technology and can be installed successively according to changes in energy demands.[4] The small size and advanced safety features of SMRs limit the effects on the surrounding environment, allowing these reactors to meet applicable safety and environmental standards more easily than their predecessors. As a result, SMRs have the potential to overcome the massive delays and cost overruns that plague the current nuclear fleet.[5]

Part I of this Comment offers a background on the regulations imposed on nuclear power producing facilities by the Nuclear Regulatory Commission (NRC) and National Environmental Policy Act of 1969 (NEPA) and explains their roles in the regulatory process. Part II describes the current nuclear fleet, the problems associated with constructing these reactors, and the construction delays which cause current reactors to be noncompetitive in today's energy market. This section then analyzes how the applicable NRC and NEPA regulations affect traditional large reactors. Lastly, Part II introduces the concept of large reactor construction as megaprojects and discusses the drawbacks associated with megaprojects. Part III describes the new SMR technology and analyzes its compliance with both NRC and NEPA regulations, discussing the advantages that SMRs have in completing the licensing and permitting processes. Part III also discusses the practical benefits of SMRs compared to the current nuclear fleet. Finally, Part IV illustrates how SMRs offer a viable solution for producing marketable nuclear energy moving forward and examines the practicality of using SMRs in tandem with renewable energy sources to create a reliable carbon-free energy system.

---

[2] *See Abundant Power from Atom Seen; It Will Be Too Cheap for Our Children to Meter, Strauss Tells Science Writers*, N.Y. TIMES (Sept. 17, 1954), https://www.nytimes.com/1954/09/17/archives/abundant-power-from-atom-seen-it-will-be-too-cheap-for-our-children.html [https://perma.cc/F4AR-AG4R].

[3] *See NRC Approves First U.S. Small Modular Reactor Design*, OFF. OF NUCLEAR ENERGY (Sept. 2, 2020), https://www.energy.gov/ne/articles/nrc-approves-first-us-small-modular-reactor-design [https://perma.cc/8TF8-HDKV].

[4] *See* Bruce R. Huber, *The New Nuclear? Small Modular Reactors and the Future of Nuclear Power*, 1 NOTRE DAME J. EMERGING TECH. 458, 460 (2020).

[5] *See* Diane Cardwell, *The Murky Future of Nuclear Power in the United States*, N.Y. TIMES (Feb. 18, 2017), https://www.nytimes.com/2017/02/18/business/energy-environment/nuclear-power-westinghouse-toshiba.html [https://perma.cc/SZ47-SLZF].

I. BACKGROUND: ASSIGNING THE ROLES OF NUCLEAR REGULATION

Following World War II, the U.S. government sought to incentivize the advancement of nuclear energy, transitioning from the creation of weapons of mass destruction to more peaceful applications of atomic power.[6] In furtherance of this goal, Congress passed the Atomic Energy Act of 1946 which, among other things, established the Atomic Energy Commission (AEC), the first nuclear regulatory body in the U.S.[7] In 1954, Congress replaced the 1946 version of the Atomic Energy Act with the Atomic Energy Act of 1954, granting the AEC the power to regulate nuclear energy development.[8] Specifically, the AEC was tasked with both encouraging the development of nuclear power and establishing regulations to ensure public safety.[9] By the 1960s, the AEC had become the subject of considerable public scrutiny with many opponents, asserting that the AEC's rules and regulations regarding radiation control, environmental protection, and overall public safety were far too relaxed.[10] By 1974, the AEC had undergone "such strong attack that Congress decided to abolish the agency."[11]

Under the Energy Reorganization Act of 1974, Congress established the Nuclear Regulatory Commission (NRC) as the new regulatory body for nuclear power in the U.S.[12] This was done in an effort to separate the promotional and regulatory duties of nuclear power into different agencies, assigning regulatory duties to the NRC and promotional duties to the U.S. Energy Research and Development Administration.[13] The NRC is the current regulatory body governing U.S. nuclear power development,

---

[6] OFF. OF NUCLEAR ENERGY, SCI. & TECH., U.S. DEP'T OF ENERGY, THE HISTORY OF NUCLEAR ENERGY, DOE/NE-0088, at 8 (2002), https://www.energy.gov/sites/default/files/The%20History%20of%20Nuclear%20Energy_0.pdf [https://perma.cc/83N9-52T9].

[7] *See History*, U.S. NUCLEAR REGUL. COMM'N, https://www.nrc.gov/about-nrc/history.html [https://perma.cc/EKZ9-35BL] (last updated Sept. 10, 2021).

[8] *Id.*

[9] *See id.* ("The AEC's regulatory programs sought to ensure public health and safety from the hazards of nuclear power without imposing excessive requirements that would inhibit the growth of the industry.").

[10] SAMUEL WALKER & THOMAS R. WELLOCK, OFF. OF THE SECRETARY, U.S. NUCLEAR REGUL. COMM'N, 2 NUREG/BR-0175, A SHORT HISTORY OF NUCLEAR REGULATION, 1946-2009, at 25 (2010), https://www.nrc.gov/docs/ML1029/ML102980443.pdf [https://perma.cc/NAY3-U33L].

[11] *See History*, *supra* note 7.

[12] *See id.*

[13] *See id.*; *see also* WALKER & WELLOCK, *supra* note 10, at 49.

focusing mainly on reactor permitting and licensing.[14] All nuclear reactors in operation today were licensed under the NRC's two-step permitting process.[15] This process requires those seeking to build a nuclear power plant ("licensees") to obtain both a construction permit and an operating license to build and operate a nuclear power plant.[16] To speed up the permitting process, the NRC instituted a program in 1989 which allows those seeking to build nuclear power plants to essentially combine the construction permit and operating license into a single license called a Combined License ("COL").[17]

The National Environmental Policy Act of 1969 (NEPA) "declare[s] a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment . . . and stimulate the health and welfare of man . . . ; and to establish a Council on Environmental Quality."[18] NEPA requires all government agencies to balance the benefits of all major federal actions with the impact those actions will have on the environment.[19] This includes evaluating "impacts on air; water; animal life; vegetation; natural resources; and property of historic, archaeological, or architectural significance" as well as any economic, social, and cultural impacts the proposed construction may have.[20]

In 1971, the D.C. Circuit Court of Appeals established the review of environmental impacts as an integral role of the AEC, representing a major turning point in nuclear reactor production in the U.S.[21] In *Calvert Cliffs'*, the court held that NEPA requires environmental concerns to be evaluated on a case-by-case basis for a reactor to be properly licensed.[22] The federal agency must then present these environmental concerns in a "detailed statement" covering the impact of the proposed action on the environment.[23] The court also determined that where the environment is

---

[14] *See History*, *supra* note 7.

[15] *See* U.S. NUCLEAR REGUL. COMM'N, NUREG/BR-0298, NUCLEAR POWER PLANT LICENSING PROCESS 1 (2009) [hereinafter NUCLEAR POWER PLANT LICENSING PROCESS], https://www.nrc.gov/docs/ML0421/ML042120007.pdf [https://perma.cc/7P44-R744].

[16] *See id.*

[17] *See id.*

[18] 42 U.S.C. § 4321.

[19] *See id.*

[20] NUCLEAR POWER PLANT LICENSING PROCESS, *supra* note 15, at 3.

[21] Calvert Cliffs' Coordinating Comm., Inc. v. U.S. Atomic Energy Comm'n, 449 F.2d 1109, 1122 (D.C. Cir. 1971).

[22] *Id.* at 1116.

[23] *Id.* at 1114.

negatively affected, NEPA requires alternative plans to be considered.[24] When considering these alternatives, the AEC must balance the technical benefits of the proposed action with the negative impacts of such action on the environment.[25] This case established the review of environmental impacts as an integral role of the AEC and represents a major turning point in production of nuclear reactors in the U.S.[26] These mandatory environmental reviews are the source of major delays that plague nuclear reactor construction and have largely led to the downfall of the U.S. nuclear industry.

II. LARGE NUCLEAR REACTORS AND MEGAPROJECTS

Nuclear power reactors were pioneered in the U.S. in the early 1960s.[27] The first working reactor was designed by Westinghouse Electric Corporation ("Westinghouse") and had an output capacity of 250 Megawatts electric ("MWe").[28] This reactor began operating in 1960 and continued to run for several decades until it was finally decommissioned in 1992.[29] Westinghouse's innovation sparked nationwide interest in nuclear energy which soon led to orders being placed for reactor units with more than 1000 MWe by the end of the 1960s.[30] Early projections for the future of nuclear power were optimistic, and expectations for its impact on the U.S. energy market were high. Many believed that once in production nuclear energy would be "too cheap to meter."[31]

Unfortunately, problems in the construction of these major nuclear developments began to arise almost immediately.[32] Construction costs for most plants quickly began to surpass projections, delays in project timelines caused capital costs to rise even higher, and the predicted increase in demand for electricity in the U.S. markets failed to

---

[24] *See id.*

[25] *Id.*

[26] *See id.*

[27] *See Outline History of Nuclear Energy*, WORLD NUCLEAR ASS'N, https://world-nuclear.org/information-library/current-and-future-generation/outline-history-of-nuclear-energy.aspx [https://perma.cc/ZEW4-6766] (last updated Nov. 2020).

[28] *Id.*

[29] *Id.*

[30] *Id.*

[31] *Abundant Power from Atom Seen; It Will Be Too Cheap for Our Children to Meter, Strauss Tells Science Writers*, *supra* note 2 (quoting Lewis L. Strauss, Chairman, Atomic Energy Comm'n, Address at the Twentieth Anniversary of the National Association of Science Writers (Sept. 16, 1954)).

[32] *See* Huber, *supra* note 4, at 460.

materialize.[33] Adding fuel to the fire, the Three Mile Island accident of 1979 ignited a public belief that nuclear reactors were dangerous and unfit for residential power needs.[34] With capital costs soaring and public opinion generally disfavoring nuclear reactors, construction and licensing of nuclear reactors came screeching to a halt, from which the U.S. nuclear market has never fully recovered.[35]

Of the hundreds of reactors that have been commissioned in the U.S., only 57 plants remain operational today.[36] This meager completion rate is due, in large part, to the complexity of the plant design and the extremely high capital costs associated with projects of this magnitude.[37] As nuclear reactors have grown in complexity so too have the safety measures required to ensure that both the public and the environment remain protected.[38] To ensure adequate protection, nuclear reactors must be built near bodies of water on large tracts of land and must be positioned far from densely populated areas and in geologically favorable locations.[39]

As a result of their extremely high capital costs, complex designs, and numerous location challenges, traditional large nuclear reactors almost always greatly exceed their budgets, rendering them unable to survive in a competitive energy market. SMRs are the solution to these construction problems because their small, modular nature allows them to circumvent these issues.

---

[33] *See id.*

[34] *See* Nathan Hultman & Jonathan Koomey, *Three Mile Island: The Driver of US Nuclear Power's Decline?*, 69 BULL. ATOMIC SCIENTISTS 63 (2013).

[35] *See id.*

[36] *Frequently Asked Questions (FAQs): How Many Nuclear Power Plants Are in the United States, and Where Are They Located?*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/tools/faqs/faq.php?id=207&t=21 [https://perma.cc/C85U-JLDL] (last visited Oct. 19, 2021).

[37] *See Economics of Nuclear Power*, WORLD NUCLEAR ASS'N, https://www.world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx [https://perma.cc/E6ER-YX8R] (last updated Sept. 2021).

[38] *Id.*

[39] *See* Lydia DePillis, *A Nuclear Power Plant with a View: How Do Energy Companies Decide Where to Build New Reactors?*, SLATE (July 21, 2009, 2:37 PM), https://slate.com/news-and-politics/2009/07/how-do-energy-companies-decide-where-to-build-nuclear-power-plants.html [https://perma.cc/GZY5-63GL].

A. Reactor Site Safety

Nuclear reactors are usually built on tracts of land that consist of at least 500 acres.[40] This space is necessary to house heat management facilities, computing facilities, fuel and waste storage areas, and the reactor itself.[41] The NRC further requires the reactor site to be located far enough away from any densely populated residential centers that an individual's exposure to radiation—in the event of an accident—would be below a specified dose of harmful radiation.[42] The magnitude of this distance is proportional to the size of the reactor and the safety measures incorporated into the plant's design.[43] The standard size of this emergency zone is ten miles for current nuclear facilities.[44] The large size and complexity of these nuclear plant sites means that more factors must conform to the NRC regulations imposed by NEPA. The most significant factors that must be considered are the exclusion area and low population zones, population considerations, emergency planning, effects on local species,[45] water availability, and water quality.[46]

One safety requirement imposed by the NRC is an "exclusion area" around the reactor.[47] The exclusion area is a space "surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from

---

[40] *Id.*

[41] *Id.*

[42] COMM'N OFF. OF NUCLEAR REGUL. RSCH., U.S. NUCLEAR REGUL. REGULATORY GUIDE 4.7: GENERAL SITE SUITABILITY CRITERIA FOR NUCLEAR POWER STATIONS, at A-3 (2014) [hereinafter REGULATORY GUIDE 4.7], https://www.nrc.gov/docs/ML1218/ML12188A053.pdf [https://perma.cc/3REA-MXDR].

[43] *See id.* ("The required distances to the exclusion area boundary and the outer boundary of the LPZ will depend on plant design aspects, such as the reactor power level, allowable containment leak rate, and those engineered safety features incorporated in the design, as well as the atmospheric dispersion characteristics of the site.").

[44] Jeremy Dillon & Kristi E. Swartz, *NRC Holds First Hearing for Small Modular Reactor Site*, E&E NEWS (Aug. 15, 2019, 6:57 AM), https://www.eenews.net/energywire/stories/1060954519/print [https://perma.cc/6VDD-6XZM].

[45] This includes factors such as: preservation of important habitats, migratory routes of important species, entrainment and impingement of aquatic organisms, and entrapment of aquatic organisms. *See* REGULATORY GUIDE 4.7, *supra* note 42, at B-5.

[46] *See id.*

[47] *See generally* 10 C.F.R. pt. 100 (2021).

the area."[48] The size of the exclusion area is determined by the minimum distance from the reactor a person would need to be located to receive less than a certain concentration[49] of total body radiation after two hours of exposure following a radiation leak.[50] This area is immediately surrounded by a low population zone ("LPZ"), and the size of the LPZ is similarly determined by the distance which, at its outer boundary, a person would receive a radiation dose less than a certain full body concentration[51] of radiation after any amount of time following a radiation leak.[52] Additionally, the LPZ must be a minimum distance away from the "nearest boundary of a densely populated center";[53] this distance is directly proportional to the distance from the reactor to the outer boundary of the LPZ.[54] Both the exclusion area and the LPZ are proportional to the size of the reactor. Thus, the larger the reactor, the greater the amount of radiation that could potentially leak out, thereby requiring the reactor to be placed farther away from populated areas. This increases the amount of land needed to host a nuclear reactor, which consequently increases the cost and time needed to establish these safe zones.

Other major considerations in the nuclear reactor construction process are emergency planning and security. In general, the NRC requires that a reactor site be capable of having an emergency plan prepared for a specified zone surrounding the reactor.[55] This emergency plan must meet the NRC's 16 specified standards for the applicant to be approved for an operating license.[56] The average sizes of these required emergency planning zones ("EPZs") are roughly a ten- and a 50-mile radius from the

---

[48] 10 C.F.R. § 100.3; *see also id.* ("Residence within the exclusion area shall normally be prohibited.").

[49] The certain concentration is 25 rem. *See id.* § 100.11(a).

[50] *Id.*

[51] The certain concentration is, again, 25 rem. *See id.*

[52] *Id.*

[53] REGULATORY GUIDE 4.7, *supra* note 42, at 17.

[54] *See id.* at A-3 ("The size of the LPZ must be such that the distance to the nearest boundary of a densely populated center with more than 25,000 residents is at least one-and-one-third times the distance from the reactor to the outer boundary of the LPZ.").

[55] *See id.* at A-5 ("The site should be examined and evaluated to determine whether any characteristics would pose a significant impediment to taking actions to protect the public in an emergency."); s*ee also* 10 C.F.R. § 100.20.

[56] *See* 10 C.F.R. § 50.47(b).

reactors for the plume[57] and ingestion[58] exposure pathways, respectively.[59] Additionally, an evacuation time estimate ("ETE") must be prepared to "estimate the time that would be required to evacuate various sectors of the plume exposure EPZ, including the entire EPZ."[60] These ETEs must consider population distribution and special population groups to assess the practicality of taking protective measures for the population area surrounding the reactor site in the event of an emergency.[61] Taking into account the physical characteristics of the proposed site, security plans must also be formed to protect from "radiological sabotage."[62] The implications of the size of the reactor on the EPZ are similar to those on the aforementioned exclusion areas: the larger the reactor, the bigger the EPZ must be and, thus, the more complex the plan. This is because a larger EPZ encompasses more people to plan evacuation routes. The increase in complexity also increases the time and money the planners must spend studying the surrounding area and developing an emergency plan.

In *Massachusetts v. United States Nuclear Energy Commission*, petitioners challenged, among other things, the NRC's decision to grant Seabrook Nuclear Power Station a license based on an alleged deficiency in Seabrook's emergency response plan.[63] This response plan was designed to cover a ten-mile plume and 50-mile ingestion pathway EPZ surrounding Seabrook.[64] Petitioners alleged that if "specific hypothetical accidents" were to occur, Seabrook's plan "could not adequately protect the large numbers of persons who visit the ocean beaches near Seabrook on summer weekends."[65] After reviewing Seabrook's plan under a deferential standard, the court ruled that Seabrook's emergency plan was sufficient to obtain an operating license.[66] This case illustrates the type of

---

[57] *See* 44 C.F.R. § 350.2(h) ("Plume Exposure Pathway refers to whole body external exposure to gamma radiation from the plume and from deposited materials and inhalation exposure from the passing radioactive plume.").

[58] *Id.* § 350.2(i) ("Ingestion Exposure Pathway refers to exposure primarily from ingestion of water or foods such as milk and fresh vegetables that have been contaminated with radiation.").

[59] *See* REGULATORY GUIDE 4.7, *supra* note 42, at 7.

[60] *See id.* at A-6.

[61] *Id.* at 19 ("Special population groups, such as those in hospitals, prisons, schools, or other facilities, that could have special needs during an emergency should be identified.").

[62] *Id.*

[63] Massachusetts v. U.S. Nuclear Regul. Comm'n, 924 F.2d 311, 315 (D.C. Cir. 1991).

[64] *Id.* at 316.

[65] *Id.* at 317.

[66] *Id.* at 324.

legal challenges brought to oppose large reactors as a result of the massive area they affect, which serve only to further delay the construction process. These delays consequently drive up the costs of large reactors, further hindering their ability to compete in today's energy marketplace.

Traditional nuclear reactors also require massive amounts of water for emergency shutdown and cooling purposes.[67] For this reason, nuclear reactors must have access to a "highly dependable" source of water that can be used "for water consumption in the quantities needed for a nuclear power plant of the stated approximate capacity and type of cooling system."[68] These water sources must be capable of functioning as an "ultimate heat sink" for the reactor(s) in the event a reactor must be shut down.[69] Ultimate heat sinks must be capable of providing a 30-day supply of cooling water to the reactor while also meeting any additional safety measures required.[70] The licensee must also be able to obtain the applicable state, local, or regional licenses to permit the licensee to use the water for cooling purposes.[71] In addition to cooling capacity, the "minimum low flow" of the water supply should be taken into account to ensure the reactor's cooling needs can be met in any condition.[72] Use of natural water bodies for cooling purposes raises concerns over water safety near nuclear reactor sites. Considering this, the NRC requires a licensee to develop and follow a plan designed to minimize the radiation concentration to surface and groundwater as much as is practicable.[73]

---

[67] *See* DePillis, *supra* note 39.

[68] REGULATORY GUIDE 4.7, *supra* note 42, at A-7 to A-8.

[69] *See* U.S. NUCLEAR REGUL. COMM'N OFF. OF NUCLEAR REGUL. RSCH., REGULATORY GUIDE 1.27: GENERAL SITE SUITABILITY CRITERIA FOR NUCLEAR POWER STATIONS 9 (2015), https://www.nrc.gov/docs/ML1410/ML14107A411.pdf [https://perma.cc/4Y5S-NSZ6].

[70] *Id.*

[71] REGULATORY GUIDE 4.7, *supra* note 42, at 20.

[72] *Id.* at 21.

[73] *See* 10 C.F.R. § 20.1101 (2021) ("The licensee shall use . . . procedures and engineering controls . . . to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable."); *see also* 10 C.F.R. § 20.1406(a) ("Applicants for licenses, other than early site permits and manufacturing licenses . . . shall describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.").

B. Environmental Concerns

Due to the massive size of traditional nuclear reactors and their use of lakes and rivers as cooling water sources, reactor sites can have substantial impacts on the surrounding environment. These reactors can negatively impact important natural habitats and affect the migratory patterns of a variety of different species.[74] Traditional reactors can also cause substantial harm to the waters they use as well as to the organisms living in or near those waters.[75] The NRC imposes limits on environmental pollution that licensees must consider during the construction and licensing of a new reactor or plant.[76] These environmental mandates are set by statutes such as the Endangered Species Act, the Fish and Wildlife Coordination Act, the Clean Water Act, and several other environmental statutes.

The NRC requires that parties consider their impact on "[i]mportant habitats" in the area that could potentially be disrupted or destroyed by the construction and operation of nuclear power plants.[77] This requires parties to prepare environmental reports projecting their impact on endangered or threatened species, breeding areas, seasonal migratory areas, and harvestable crops.[78] Migratory patterns must not be disrupted by obstruction of the water bodies used for reactor facility purposes, allowing for normal passage of native species through the water body.[79] Additionally, intake and discharge systems for cooling water must be engineered to reduce the accidental capture of organisms.[80]

The waters used for cooling are also subject to regulation under the Federal Water Pollution Control Act (FWPCA) and the Clean Water Act (CWA).[81] The Environmental Protection Agency (EPA) and the FWPCA set the standards for water quality, which require a licensee to restore and maintain the "chemical, physical, and biological integrity of the Nation's waters."[82] The FWPCA further requires that a licensee receive certification from the state permitting discharge into applicable waters.[83]

---

[74] *See* REGULATORY GUIDE 4.7, *supra* note 42, app. B.
[75] *See id.*
[76] *See id.*
[77] *See id.* at B-1.
[78] *See id.*
[79] *See id.* at B-2.
[80] *See id.* at B-3.
[81] *See id.* at B-5.
[82] *Id.*
[83] *Id.*

This ensures all requisite state standards are met before the NRC issues a permit.[84]

The body of water that the licensee elects to use for cooling purposes must also be of sufficient quantity as to not affect other individuals' use of the water.[85] This includes the body of water being large enough to minimize the effects that the intake and subsequent discharge of the cooling water have on the water source as a whole.[86] The strict adherence to NEPA and NRC regulations causes nuclear construction projects to be delayed, driving up the costs of construction even more.

In the Vermont Supreme Court case, *In re Entergy*, environmental groups appealed a decision granting a permit amendment to Vermont Yankee for a change in its pollutant discharge system.[87] Vermont Yankee's cooling water system functioned by drawing water from the Connecticut River to remove heat from the plant and then discharging the water back into the river.[88] This discharge was subject to CWA compliance, which requires an operator to obtain a permit for lawful discharges into navigable waters.[89] Among other things, the environmental groups claimed Vermont Yankee had failed to consider the "significant impacts on [important] the species" of Atlantic salmon and American shad found in the river, including possible effects on the seasonal migration, breeding, and "cold water habitat" of the species.[90] The court found that Vermont Yankee had sufficiently considered its impacts on the Connecticut River and the species living within it, and therefore, the permit amendment was properly granted.[91]

Because they affect such a significant portion of their surrounding environment, large nuclear plants like Vermont Yankee are subject to a myriad of environmental standards, which in turn exposes them to countless lawsuits challenging their compliance with these environmental standards. Though Vermont Yankee was successful in this suit, approximately six years elapsed between the plant's application for a permit amendment in 2003 and its approval following the decision in this lawsuit in 2009.[92] *In re Entergy* further illustrates how suits brought

---

[84] *Id.*

[85] *See id.* at B-6.

[86] *See id.*

[87] *In re* Entergy Nuclear Vermont Yankee Discharge Permit 3-1199, 989 A.2d 563, 567 (2009).

[88] *Id.*

[89] *Id.*; *see also* 33 U.S.C. § 1342.

[90] *See In re Entergy*, 989 A.2d at 575, 583.

[91] *Id.*

[92] *See id.* at 569.

against large reactors can cause years of operational and construction delays. These delays consequently increase the cost of energy production from large reactors to a degree at which the energy produced is no longer economically competitive.

C. Megaprojects

For the past 15 years, Georgia Power has been expanding its Vogtle plant by adding two 1,100 MWe nuclear reactors, known as Units Three and Four.[93] These are the first reactors to be produced in the U.S. for decades, and in 2012 they became the first reactors to ever be licensed under the NRC's one-step Combined Licensing ("COL") program.[94] This program was designed by the NRC to streamline licensing of new reactors. Georgia Power commenced this project in 2006 and initially scheduled its two new reactors for completion by 2016 and 2017 with the total cost of the project estimated at $14.3 billion.[95] Units Three and Four began experiencing delays almost immediately, with construction falling five months behind schedule in June of 2011.[96] Only two months later, NRC inspectors discovered that rebar[97] had been improperly installed, pushing the project to one year behind schedule.[98]

As a result of the delays, costs began to quickly overrun projections with more than a $1 billion increase in the initial cost estimate by 2013—only three years after construction actually began.[99] The Vogtle project has continued in similar fashion throughout the years.[100] Currently, the reactors are scheduled to be operational in 2021 and 2022 respectively, with cost estimates exceeding $27 billion. This puts the project over four years behind schedule and $13 billion over budget—nearly double the initial projected costs. The problem of drastically overshooting costs is not unique to the Georgia Power project, nor even to nuclear power plant construction projects in general. Rather, it is a larger problem that plagues

---

[93] *See* Sonal Patel, *How the Vogtle Nuclear Expansion's Costs Escalated*, POWER MAG. (Sept. 24, 2018), https://www.powermag.com/how-the-vogtle-nuclear-expansions-costs-escalated/ [https://perma.cc/9S3J-9R4R].

[94] *See id.*

[95] *See id.*

[96] *See id.*

[97] Rebar is short for "reinforcing bar." *What Is Rebar?*, METAL SUPERMARKETS (June 8, 2021), https://www.metalsupermarkets.com/what-is-rebar/ [https://perma.cc/7NRP-VEHN].

[98] *See* Patel, *supra* note 93.

[99] *See id.*

[100] *See id.*

all large-scale, complex construction projects. These kinds of projects are colloquially known as "megaprojects."

Megaprojects are "large-scale, complex ventures that typically cost a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people."[101] Megaprojects encompass a wide variety of developments spanning from public works, such as the Sydney Opera House and the Olympics, to infrastructure and energy projects, such as the Channel Tunnel in Europe and the nuclear power plants currently under construction in Georgia.[102] Megaprojects are plagued by a unique set of challenges brought on by the large capital costs, extensive planning and construction times, and first-of-a-kind nature inherent to all megaprojects.[103] Taken together, these factors make megaprojects a nightmare to manage, almost always leading to massive cost and time overruns.[104]

On average, nine out of ten megaprojects experience cost overruns.[105] Moreover, only one of ten megaprojects is completed on schedule.[106] Frequent delays can quickly push projects years behind, causing further cost overruns as a result. In a study conducted by Bent Flyvbjerg, a prominent authority in the field of megaproject planning and management, it was noted that a delay of one year causes an average of 4.64% cost overrun for a megaproject.[107] If, for example, a $22 billion project was delayed by one year, the added cost to the project would be over $1 billion. In this way, a megaproject can quickly spiral into disaster, which through a "combination of escalating construction costs, delays, and increasing interest payments makes it impossible for project revenues to cover costs, rendering projects non-viable."[108] Because the energy market is largely

---

[101] *See* BENT FLYVBJERG, THE OXFORD HANDBOOK OF MEGAPROJECT MANAGEMENT 3 (Bent Flyvbjerg ed., 2017).

[102] *See id.* at 4, 9; *see also* Bent Flyvbjerg, *Design by Deception: The Politics of Megaproject Approval*, 22 HARV. DESIGN MAG. 50, 52 (describing the process by which costs associated with megaprojects are intentionally underestimated to achieve initial approval).

[103] *See* FLYVBJERG, *supra* note 101, at 8.

[104] *See id.* at 4 ("The size of megaprojects is staggering no matter what you compare with, and is matched only by the challenges of managing one.").

[105] *See id.* at 9.

[106] *See id.* at 11 ("If, as the evidence indicates, approximately one out of ten megaprojects is on budget, one out of ten is on schedule, and one out of ten is on benefits, then approximately one in a thousand [megaprojects] is a success, defined as on target for all three.").

[107] *Id.* at 10.

[108] *See id.* at 11.

unregulated, nuclear projects going over budget means higher rates must be charged to consumers to recuperate construction costs.[109] This makes nuclear energy an expensive option for electricity, putting it at an insurmountable disadvantage in a hypercompetitive energy market.[110]

The very nature of megaprojects causes them to experience excessive delays and vast cost overruns. When combined with the environmental and technical issues that inevitably complicate the construction of nuclear power plants, the idea of large nuclear megaprojects being completed on time and on budget becomes little more than a fantasy.

III. THE NUCLEAR FUTURE: SMALL MODULAR REACTORS

SMRs are beginning to be licensed for production in the U.S. as a result of clean power initiatives by both the federal government and private actors.[111] As their name implies, the key aspects of SMRs are their small size and modular construction.[112] SMRs are categorized as reactors that produce under 300 MWe, have small physical footprints, and are designed for serial production due to their modular nature.[113] The unique characteristics of SMRs allow them to be built in "controlled factory settings."[114] From there, the reactors can be transported and installed "module by module" at designated plant sites as the need for power arises.[115]

As previously mentioned, a key advantage of SMRs is their ability to adhere to one approved design, enabling them to be mass produced at a much faster and cheaper rate than traditional large nuclear reactors.[116] This capability shifts nuclear reactor production from what is known as "first-

---

[109] Huber, *supra* note 4, at 460.

[110] *See id.*

[111] *See NuScale SMR Receives US Design Certification Approval*, WORLD NUCLEAR NEWS (Sept. 1, 2020), https://world-nuclear-news.org/Articles/NuScale-SMR-receives-US-design-certification-appro.

[112] Huber, *supra* note 4, at 470.

[113] *Small Nuclear Power Reactors*, WORLD NUCLEAR ASS'N, https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx [https://perma.cc/UM69-TANP] (last updated Dec. 2021); *see also* Huber, *supra* note 4, at 472–73.

[114] *Small Nuclear Power Reactors*, *supra* note 113.

[115] *Id.* ("Because of their small size and modularity, SMRs could almost be completely built in a controlled factory setting and installed module by module, improving the level of construction quality and efficiency."); *see also* Huber, *supra* note 4, at 472.

[116] Huber, *supra* note 4, at 470.

of-a-kind" ("FOAK") projects to "nth-of-a-kind" ("NOAK") projects.[117] FOAK projects are projects whose particular design and specifications have never been built before.[118] FOAK projects present even seasoned manufacturers with "new and unsolved problems" to be resolved during construction.[119] These problems often lead to considerable delays in construction, causing significant increases in the cost of FOAK projects.[120] In contrast, NOAK production projects are repeated over and over again using the same methods and manufacturers each time.[121] NOAK projects benefit substantially from previous experience, resulting in the streamlining of production and subsequent decrease in production costs.[122] Costs of NOAK reactor production will continue to decrease as supply chains are developed via third-party production of parts.[123] This in turn creates a competitive market for reactor parts, further decreasing costs for reactor production.[124]

Though their predecessors have radiated a fear of nuclear power into public opinion, SMRs are actually remarkably safe. SMRs employ passive safety features that eliminate the need for elaborately engineered safety systems found in traditional nuclear reactors.[125] This causes SMRs to be both safer and more cost effective than their larger predecessors, meaning the reactors are also easier to license since safety is less of a concern. Passive safety features are those that do not require an external power source or safety system to function, relying "only on physical phenomena such as convection, gravity, or resistance to high temperatures, not on [the] functioning of engineered components."[126] These passive fail-safes can

---

[117] *Id.* at 472.

[118] *See* Lauren M. Boldon & Piyush Sabharwall, *Small Modular Reactor: First-of-a-Kind (FOAK) and Nth-of-a-Kind (NOAK) Economic Analysis*, IDAHO NAT'L LAB'Y 2 (2014).

[119] Huber, *supra* note 4, at 471.

[120] *See* Boldon & Sabharwall, *supra* note 118, at 2 ("It is for this reason that FOAK plants are traditionally 15-55% more expensive than subsequent non-FOAK plants.").

[121] *See id.*; *see also* Huber, *supra* note 4, at 471.

[122] *See* Huber, *supra* note 4, at 470–71.

[123] *See id.*

[124] *See id.* at 472.

[125] *See About Us*, NUSCALE, https://www.nuscalepower.com/about-us (last visited Oct. 18, 2021). NuScale, a leading company in SMR technology, states that "[their] advanced SMR design eliminates two-thirds of previously required safety systems and components found in today's large reactors." *NuScale Power*, AZO CLEANTECH, https://www.azocleantech.com/suppliers.aspx?SupplierID=1732 [https://perma.cc/92U6-H3GE] (last visited Oct. 30, 2021).

[126] Huber, *supra* note 4, at 474 n.70.

make use of gravity by releasing cooling water from pools situated above the reactors in the event that external control of the reactor is lost or the reactor begins to overheat.[127] The cooling water will then initiate reactor shutdown, after which the reactor can be turned back on once the problem has been corrected.[128]

SMRs also have a very small physical footprint compared to other power-producing plants—nuclear or otherwise.[129] The reactor units can be as small as 75 feet tall and 15 feet wide—only slightly larger than two school buses set end to end—while traditional reactors require more than a square mile to operate.[130] Due to their increased safety and smaller size, SMRs can be located much closer to residential areas than larger plants.[131] Their small size, however, also means they produce less power than larger reactors.[132] Some sites will therefore need multiple SMRs to match the energy output capabilities of larger plants. Luckily, this too works to benefit SMRs, as each reactor can be powered on independently as it is installed, allowing the plant to begin generating profits while the rest of the plant is still developing.[133] The ability to start producing profits before the plant is fully developed allows investors to reduce their capital risk by receiving a return on their investments before more money is spent to further develop the plant. As a result, SMRs are a much more cost-effective and versatile means of providing carbon-free nuclear energy to the economy. This cost efficiency is coupled with much lower risks than

---

[127] *Id.* at 474.

[128] *See NuScale Power*, *supra* note 125 ("This Triple Crown For Nuclear Plant Safety™ design safely shuts down and self-cools, indefinitely with no operator action, no AC or DC power, and no additional water.").

[129] *See Advanced Small Modular Reactors (SMRs)*, OFF. OF NUCLEAR ENERGY [hereinafter *SMRs*], https://www.energy.gov/ne/advanced-small-modular-reactors-smrs [https://perma.cc/XAM8-NZ7K] (last visited Oct. 28, 2021).

[130] *See Technology Overview*, NUSCALE, https://www.nuscalepower.com/technology/technology-overview [https://perma.cc/3MMW-5WZB] (last visited Oct. 18, 2021) ("The reactor measures 65 feet tall x 9 feet in diameter. It sits within a containment vessel measuring 76 feet tall x 15 feet in diameter."); *see also* OFF. OF NUCLEAR ENERGY, U.S. DEP'T OF ENERGY, THE ULTIMATE FACTS GUIDE TO NUCLEAR ENERGY 6 (2019), https://www.energy.gov/sites/default/files/2019/01/f58/Ultimate%20Fast%20Facts%20Guide-ebook_1.pdf [https://perma.cc/BZ8V-RM82] ("A typical 1,000-megawatt nuclear facility in the United States needs a little more than 1 square mile to operate.").

[131] *See SMRs*, *supra* note 129.

[132] Nuscale's reactors produce only 60 MWe per reactor unit. *See Technology Overview*, *supra* note 130.

[133] Huber, *supra* note 4, at 474.

traditional nuclear reactors, as SMRs require less capital investment and are less likely to face delays during licensing and construction.

A. Reactor Site Safety

SMRs are subject to the same NRC and NEPA requirements as larger nuclear reactors: exclusion area and low population zone, population considerations, emergency planning, effects on local species, water availability, and water quality.[134] Due to their smaller physical footprint, however, SMRs necessarily impact the environment less than a large nuclear facility does. This enables SMRs and their reactor sites to be licensed and constructed more efficiently than large reactor sites, as their environmental impacts are typically both smaller in scale and less severe.

As mentioned above, the exclusion area is the area surrounding the reactor that is under the authority of the reactor licensee. This area is determined by the minimum distance a person would need to be from a reactor to receive less than a certain concentration[135] of total body radiation after two hours of exposure resulting from a radiation leak.[136] Since SMRs produce less radiation than traditional large nuclear power plants, the exclusion area required for an SMR reactor would be much smaller, allowing SMRs to be placed much closer to residential areas than traditional reactors. Likewise, the LPZ[137] would be proportionally smaller due to the decreased potential radiation output of the reactor. The decreased sizes of the exclusion area and the LPZ decrease the amount of land needed to host a nuclear reactor and thereby decrease the construction costs.[138]

SMRs are significantly safer than large nuclear reactors because of their passive safety features.[139] They are also better protected from terrorist attacks and natural disasters because they are situated underground.[140] These increased safety factors translate to much smaller EPZs surrounding SMRs as well. Whereas the average size for an EPZ is traditionally ten miles, the NRC is considering a proposed rule that would establish a scalable approach for SMRs based on the distance from the reactor that harmful doses of radiation could reach, abandoning the current ten- and

---

[134] *See* REGULATORY GUIDE 4.7, *supra* note 42, at B-5.

[135] The certain concentration is 25 rem. *See* 10 C.F.R. § 100.11 (2021).

[136] *Id.*

[137] The area surrounding the exclusion area which, at its outer boundary, a person would receive less than 25 rem of total body radiation. *See id.*

[138] *See Economics of Nuclear Power*, *supra* note 37.

[139] *See SMRs*, *supra* note 129; *see also* Huber, *supra* note 4, at 474 n.70.

[140] *See SMRs*, *supra* note 129.

50-mile standards for EPZs.[141] Early predictions of EPZs for SMRs are as small as a two-mile radius.[142] Reduction of the size of the EPZ also necessarily reduces the time and costs associated with planning, decreasing the overall cost of the SMR project.

Whereas traditional nuclear reactors require large amounts of water for emergency shutdown and cooling purposes, SMRs rely on passive safety features inherent in their designs.[143] These small reactors can rely solely on a water tank placed above the reactor instead of requiring a moderately sized lake or river for cooling.[144] This effectively eliminates the requirement that a reactor site be located near a body of water, allowing SMRs to be placed in a wide variety of locations not accessible to large reactors. In other words, it makes meeting the NRC's requirement of a "highly dependable" water source as simple as installing a water tank.[145] Though SMRs will still need to develop plans for decreasing surface water and groundwater radiation, the fact that most SMRs will be buried underground and do not require natural waters for cooling will drastically decrease their chances of causing harmful levels of radiation to nearby water sources.[146]

B. Environmental Concerns

As a consequence of their relatively limited interaction with the environment, SMRs have a significantly smaller environmental impact compared to larger nuclear, natural gas, or coal-burning facilities. Meeting

---

[141] *See* Jeremy Dillon & Kristi E. Swartz, *NRC Takes Significant Steps on Reactor Licensing*, E&E NEWS (Dec. 17, 2019, 4:52 PM), https://www.eenews.net/eenewspm/stories/1061837749/search?keyword=tva%27s+plan+for+small+reactors+clears.

[142] *See id.* ("TVA provided methodology that demonstrated its planning zone for its site could be reduced to as far as 2 miles. In its environmental impact statement, the NRC staff took no issue with such methodology.").

[143] *See* Huber, *supra* note 4, at 474 n.70.

[144] *See id.* at 474.

[145] *See* REGULATORY GUIDE 4.7, *supra* note 42, at A-7.

[146] *See* 10 C.F.R. § 20.1101(b) (2021) ("The licensee shall use . . . procedures and engineering controls . . . to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable."); *see also* 10 C.F.R. § 20.1406(a) ("Applicants for licenses, other than early site permits and manufacturing licenses . . . shall describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.").

NRC and NEPA mandated environmental standards is therefore much easier for SMRs. Due to their placement underground, SMRs are likely to have substantially less impact on important habitats and on animals' migratory patterns.[147] Aquatic animals and water quality are likewise unlikely to be affected, as SMRs do not require use of natural water bodies to safely operate. SMRs operators will also not need to apply for certification from the FWPCA because they will not need to discharge pollutants into any of the nation's waters.[148] Additionally, other concerns regarding local water pollution can largely be put to rest given SMRs' limited contact with public waters. Their limited interaction with the environment further reduces the time needed to license and construct SMRs and thus makes them a more financially and environmentally sound option for achieving clean, reliable energy.

IV. A TECHNOLOGICAL SOLUTION TO A REGULATORY PROBLEM

Large nuclear reactor construction and operation suffer from a variety of regulatory issues causing the energy produced to become too expensive to effectively market. The solution to these regulatory issues is SMR technology. SMRs represent a beacon of hope—or perhaps an emergency flare for an industry in need of rescue—for the practical use of sustainable nuclear energy. The versatility and safety of SMRs enable them to be utilized in eliminating the need for carbon-based energy sources entirely because although the energy provided by renewables such as solar and wind power is clean, it is not reliable. The fundamental weakness of renewables is dependence on optimal weather conditions. Because renewable energy cannot yet be effectively stored for long periods of time, an especially cloudy or windless day could leave communities that operate solely on renewables without power for as long as it takes for favorable weather conditions to return.[149] When used in tandem with SMRs, however, renewable energy could serve as a reliable source of energy for a completely carbon-free energy market.

Unlike natural gas, coal-burning, and large nuclear facilities, SMRs are capable of switching on and off to suit current energy demands.[150] This means when conditions are favorable and renewables are producing substantial amounts of energy, SMRs can be switched off as needed to prevent energy waste.[151] On the other hand, when renewable energy

---

[147] *See* REGULATORY GUIDE 4.7, *supra* note 42, at B-1.

[148] *See id.* at B-5.

[149] *See* Huber, *supra* note 4, at 467.

[150] *Id.* at 460.

[151] *See id.*

production is insufficient to meet demand, SMRs can simply be switched on to satisfy power needs.[152] Essentially, energy production could be scalable to current demands which would reduce energy cost as well as waste.

SMRs allow for a degree of versatility in meeting energy demands not available in the current market. This versatility would also allow SMRs to be used for the creation of smaller power grids, known as "microgrids." Microgrids are more efficient and can be controlled more acutely than larger electrical grids. A simple advantage of microgrids is that power outages will affect smaller areas, only powering down the small portion of the grid that is affected. This means more reliable power for more people.

A notable example of the practical advantages that SMRs can provide is how they could have been used to avoid major disasters such as the Texas power crisis of 2021. In February of 2021, an extreme and historic cold front overtook the southern U.S., causing radical effects on the energy infrastructure of several states. The intense cold caused many power generators—natural gas, coal, solar, large nuclear, and wind alike—to cease energy production as their utilities proved ill-prepared to handle the brutal cold. Nowhere was this more prevalent than Texas, where reports of state-wide blackouts received national media attention, left millions of people without power, and eventually led to the deaths of over 200 people.[153] Damages from the blackouts are estimated at over $195 billion in damages, making it the most expensive disaster in Texas to date.[154] Numerous lawsuits have already been filed against Texas energy providers for their failure to keep the lights on.[155]

To understand why Texas in particular was hit so hard, it is important to first understand the basics of Texas's energy structure. In addition to being a deregulated energy market, Texas is the only state in the U.S. to

---

[152] *Id.*

[153] *See* Andrew Weber, *Texas Winter Storm Death Toll Goes Up to 210, Including 43 Deaths in Harris County*, HOUS. PUB. MEDIA (July 14, 2021, 2:07 PM), https://www.houstonpublicmedia.org/articles/news/energy-environment/2021/07/14/403191/texas-winter-storm-death-toll-goes-up-to-210-including-43-deaths-in-harris-county/#:~:text=The%20Texas%20Department%20of%20State,because%20of%20the%20winter%20storm [https://perma.cc/8XUM-ZUMP].

[154] *See* Matthew Hall, *The Great State of Texas: Explaining the Power Crisis and What Happens Next*, POWER TECH. (May 24, 2021), https://www.power-technology.com/features/the-great-state-of-texas-explaining-the-power-crisis-and-what-happens-next/ [https://perma.cc/8DBH-25RC].

[155] *See, e.g.*, *In re* Winter Storm Uri Litigation, No. 21-0313 (Tex. Apr. 7, 2021).

independently run its power grid without federal oversight.[156] Because Texas's energy market is deregulated and operates independently, Texas cannot rely on energy coming from out-of-state as a backup in the event of an emergency.[157] What this means is that Texas is essentially an "energy island" when it comes to energy transmission.[158] While other states are able to draw from the veritable ocean of electricity flowing through and produced by neighboring states, Texas is left shipwrecked when disaster strikes.[159]

In response to Texas's power vulnerabilities being exposed, proposals are being made on how best to make Texas's energy system more stable and reliable.[160] One leading proposal is the implementation of microgrids.[161] Implementation of microgrids would limit the area affected when larger transmission lines go down and allow use of any local residential solar panels to power an individual grid. Microgrids alone, however, do not solve Texas's reliability problem. The glaring issue with renewables such as solar and wind is that when weather conditions are not ideal, energy production suffers or ceases altogether. In fact, solar panel and wind turbine failure accounted for roughly 13% of total power loss during the Texas power crisis.[162] Without a reliable source of backup power, there is little standing in the way of another power crisis. This is where SMRs come in.

The implementation of SMRs into neighborhood-sized microgrids would allow Texas to sustain a reliable source of backup power while maintaining its energy independence from the rest of the continental U.S. Texas could continue to offer natural gas when cheaper and simply switch on its SMRs when gas prices make them marketable. More importantly,

---

[156] *See* Hall, *supra* note 154.

[157] *See* Garrett T. Galvin, *Lone Star Solar: Challenges and Opportunities in Post-Blackout Texas*, NAT'L L. REV. (Apr. 5, 2021), https://www.natlawreview.com/article/lone-star-solar-challenges-and-opportunities-post-blackout-texas [https://perma.cc/L759-P2QM].

[158] *Id.*

[159] *See id.* ("All of the other 47 states in the continental United States connect their grids to either the Eastern Interconnection grid or the Western Interconnection grid, and these multi-state systems maintain the ability to transmit power from one region to another, serving as a useful safeguard against grid failures during extreme, relatively local weather events.").

[160] *See id.* ("Since the energy crisis, Texas lawmakers have advanced a number of proposals and amendments to prevent similar, or more severe, crises in the future while maintaining energy independence from the rest of the continental United States . . . .").

[161] *See id.*

[162] *See id.*

SMRs could be readily switched on in case of an emergency. Unlike solar, wind, and even fossil fuels, SMRs are far less susceptible to inclement weather. This is because they are buried underground, and as such, are shielded come hell, highwater, or deep freeze.

SMRs are also cost competitive with natural gas sources. Natural gas is currently the cheapest source of energy, but it produces massive amounts of greenhouse gases in its energy production. By decreasing the cost of reactors through serial production and enabling systematic activation of SMRs as larger plants are built, the costs of nuclear energy shrink immensely. Even if nuclear costs decrease, however, natural gas will likely continue to be cheaper in the current deregulated energy market. For this reason, a carbon tax should be imposed on power plants which would tax the plant per specific volume of carbon dioxide produced. This would essentially level the playing field between nuclear and natural gas plants and incentivize companies to seek greener energy alternatives. With the depletion of fossil fuels and the growing concern over climate change, it may be the perfect time for nuclear power to step up to the plate.

CONCLUSION

In its current state, nuclear energy is not a viable source for energy production in a competitive energy market. Construction of traditional large nuclear reactors is plagued by cost overruns and delays that can push projects back several years and cost billions of dollars more than projected. Construction delays are a result of the complex management endemic to megaprojects as well as extensive environmental compliance mandated by NEPA and the NRC. Cooling and safety requirements necessary for large nuclear reactor design all but require these reactors to have a large impact on the environment. Extensive cooling water systems and large emergency planning zones drastically limit the areas where nuclear reactors can be placed and add years of delay to a project. In contrast, SMRs offer a promising solution to the problem of sourcing economically viable nuclear energy in the U.S. SMRs can be produced in factories at much faster rates for a fraction of the cost of traditional reactors and are not subject to many of the regulatory delays that have historically plagued the nuclear industry. SMRs can also be used alongside renewable energy sources to create reliable carbon-free energy and smaller, more efficient energy grids. With all the advantages that SMRs bring, they offer a promising look at attaining truly clean energy.