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Ashley Hardy
Arizona State University Sandra Day O'Connor College of Law (Student)

Dontan Hart
Arizona State University Sandra Day O'Connor College of Law (Student)

POLICY MELTDOWN: HOW CLIMATE CHANGE IS DRIVING EXCESSIVE NUCLEAR ENERGY INVESTMENT

Ashley Hardy & Dontan Hart[*]

The United States is currently experiencing what some have labeled a nuclear energy renaissance. This so-called renaissance responds in part to growing concerns about global warming and the need to reduce the greenhouse gas emissions associated with electricity production. A growing number of policymakers and scholars view nuclear energy development as one of the most promising means of slowing climate change because nuclear energy does not produce greenhouse gas emissions. They are increasingly advocating that nuclear energy receive policy treatment at least as favorable as that afforded to renewable energy strategies such as wind and solar energy. Some state governments are also citing global warming as a primary reason for investing millions to extend the lives of aging nuclear power plants and to keep these plants operational and cost-competitive in an era of low-cost natural gas. Unfortunately, in their zeal to save nuclear energy plants and promote additional nuclear energy development as a means of combatting global warming, policymakers are underestimating the true costs associated with nuclear power in ways that could adversely impact humankind for centuries to come.

This Article applies familiar principles of microeconomics and behavioral economics to analyze the nation's recent flirtation with nuclear energy as a primary response to global warming. Among other things, policymakers and the public seem to increasingly allow excessive optimism, myopia, path dependence problems, or intergenerational externality problems resulting in their under-consideration of the full social costs of nuclear energy. This Article ultimately argues that, when one considers all the

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[*] Both authors are Sustainability Law Student Research Fellows and 2018 JD Candidates within the Program on Law & Sustainability at Arizona State University's Sandra Day O'Connor College of Law. This Article was researched and written under the supervision and guidance of Professor Troy A. Rule, Faculty Director of Arizona State University's Program on Law & Sustainability. The authors wish to thank the other Sustainability Student Research Fellows and Professor Rule for their invaluable input in this Article.

societal costs of nuclear energy, renewable energy strategies such as wind and solar development are a far more cost-justifiable means of responding to global warming.

INTRODUCTION

In August of 2016, the New York State Public Service Commission approved a $7.6 billion bailout for the state's aging nuclear facilities.[1] According to New York Governor Andrew Cuomo, the bailout was intended to keep the plants operational in the face of low market prices for natural gas which, according to nuclear power plant owners, were making the plants' continued operation uneconomical.[2] Interestingly, the Commission's justification for expending so much money to keep the nuclear plants running was New York's "Clean Energy Standard." The Standard requires the State to generate 50 percent of its electricity from renewable energy sources.[3] Specifically, the Commission asserted that this additional funding to prop up nuclear power plants would "significantly reduce harmful greenhouse gas emissions and prevent backsliding on progress made to date by maintaining the operations of carbon-free nuclear power plants as the State transitions to a 50 percent renewable energy requirement."[4] New York's Clean Energy Standard seemingly places nuclear power in the same category for public policy purposes as wind and solar energy.[5]

New York's justification for treating nuclear power as though it were as environmentally friendly as wind and solar was

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[1] *See* Karl Grossman, *New York Approves $7.6 Billion Bailout of Nuclear Power Plants,* THE HUFFINGTON POST (Aug. 3, 2016) http://www.huffingtonpost.com/karl-grossman/76-billion-bailout-of-ny-_b_11302708.html.

[2] *See id.*

[3] *See Governor Cuomo Announces Establishment of Clean Energy Standard that Mandates 50 Percent Renewables by 2030,* N.Y. STATE (Aug. 1, 2016), https://www.governor.ny.gov/news/governor-cuomo-announces-establishment-clean-energy-standard-mandates-50-percent-renewables (stating that the renewable energy used to support the Clean Energy Standard will include solar, wind and nuclear energy).

[4] *See id.*

[5] *See id.*

that nuclear power plants do not emit carbon or greenhouse gases.[6] This argument has become increasingly common in recent years in the face of growing concerns about human-induced climate change. Unfortunately, although nuclear energy has some beneficial characteristics that coincide with those of renewable energy strategies, such as wind and solar, it arguably underestimates the sizable costs imposed on society. These costs potentially far exceed those of conventional renewable energy sources.

According to the Nuclear Energy Institute, there are currently six nuclear energy plants operating in New York State.[7] In 2016, one of these plants, Indian Point, underwent analysis by the Nuclear Regulatory Committee in connection with a petition to extend the plant's two forty-year-old reactors for another twenty years.[8] The Indian Point nuclear facility is located in Buchanan, New York, which is roughly twenty-four miles from New York City.[9] Entergy, the energy company that owns the Indian Point facility, and the Nuclear Regulatory Commission (NRC), designated a ten-mile radius around the plant, long ago, as an evacuation "Emergency Planning Zone," in case of a "radiological emergency."[10] A radiological emergency would arise if any significant quantity of radioactive material escaped from the plant.[11] This ten-

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[6] Grossman, *supra* note 1 (stating that the Clean Energy Standard is claiming "that nuclear power is comparable because nuclear plants don't emit carbon or greenhouse gases—the key nuclear industry argument for nuclear plants nationally and worldwide these days because of climate change").

[7] *See Fact Sheet: New York and Nuclear Energy,* NUCLEAR ENERGY INST., 1, 2 https://www.nei.org/CorporateSite/media/filefolder/Backgrounders/Fact-Sheets/State%20Fact%20Sheets/New-York-State-Fact-Sheet.pdf?ext=.pdf

[8] *See* Jeff Tollefson, *Nuclear power plants prepare for old age,* 537 NATURE 16, 16 (Sept. 1, 2016) http://www.nature.com/polopoly_fs/1.20499!/menu/main/topColumns/topLeftColumn/pdf/537016a.pdf..

[9] *See* Vivian Yee & Patrick McGeehan, *Indian Point Nuclear Power Plant Could Close by 2021*, N.Y. TIMES (Jan. 6, 2017) https://www.nytimes.com/2017/01/06/nyregion/indian-point-nuclear-power-plant-shutdown.html.

[10] *See Emergency Planning Zone: Protecting Health and Safety,* INDIAN POINT ENERGY CTR., http://www.safesecurevital.com/emergency-preparedness/emergency-planning.html (last visited Feb. 26, 2017).

[11] *Id.* (defining a "radiological emergency at Indian Point would mean that radioactive materials either escaped or could possibly escape from the plant. The

mile emergency planning zone has remained the same size since it was first introduced in 1978, despite substantial population growth around the plant since that time.[12] The zone's size is based upon analyses done in 1978, from which the NRC and Environmental Protection Agency (EPA) concluded that an accident creating radiation hazards dire enough to require evacuation more than ten miles was very unlikely.[13] In contrast, the NRC advised Americans to evacuate a minimum of fifty miles from the Fukushima Daiichi facility, in Japan, after the 2011 Fukushima Daiichi nuclear plant meltdown.[14]

Recent ultrasonic tests at Indian Point identified noticeable "wear and tear" on some of the stainless-steel bolts located inside the reactor core.[15] If an evacuation within a fifty-mile radius was necessary at Indian Point in the event of a full scale nuclear meltdown, it would encompass 17.6 million people—six percent of the United States population, including parts of New Jersey and Connecticut, and most of New York City.[16] New York City's

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materials would be in the form of a vapor or very fine particles that, if released to the air, would be carried by the wind").

[12] Edward Moore Geist, *What Three Mile Island, Chernobyl, and Fukushima can teach about the next one,* BULL. ATOMIC SCIENTISTS (Apr. 28, 2014), http://thebulletin.org/what-three-mile-island-chernobyl-and-fukushima-can-teach-about-next-one7104.

[13] *See* H. E. COLLINS ET AL., PLANNING BASIS FOR THE DEVELOPMENT OF STATE AND LOCAL GOVERNMENT RADIOLOGICAL EMERGENCY RESPONSE PLANS IN SUPPORT OF LIGHT WATER NUCLEAR POWER PLANTS I-10 (1978), https://www.nrc.gov/docs/ML0513/ML051390356.pdf (stating that there is about a 1% chance of emergency plans being activated beyond the recommended 10 miles zone and that there is a very small probability that releases larger than those from design basis accidents used in evaluating the acceptability of the reactor site could occur which would have consequences substantially in excess of the PAG levels outside the lower population zone outer boundary).

[14] *See* Frank N. von Hippel, *The radiological and psychological consequences of the Fukushima Daiichi accident*, 67 BULL. ATOMIC SCIENTISTS 27 (2015) ("[o]n March 6, 2011, the Nuclear Regulatory Commission advised Americans in the region to evacuate out to 50 miles").

[15] *See* Tollefson, *supra* note 8 (discussing research performed at the Electric Power Research Institute in Palo, Alto, California).

[16] Julie Jacobson, Associated Press, *AP: Populations around U.S. nuclear plants soar*, U.S.A TODAY (Jun. 27, 2011, 12:43 PM) http://usatoday30.usatoday.com/

Deputy Commissioner of Preparedness, Kelly McKinney, has stated that "such a mass exodus would be an enormous challenge because at no time in the history of man has anyone tried to move seventeen million people in forty-eight hours."[17] One advocacy group has estimated that a nuclear meltdown at one of Indian Point's units would result in as many as "44,000 short term fatalities from radiation exposure, 518,000 latent cancer fatalities, $2 trillion in property damage, and the relocation of eleven million people."[18] Even the NRC's own 1982 report estimated that the impact of a severe reactor incident at Indian Point would be "46,000 Peak Early Fatalities, 141,000 Peak Early Injuries, and 13,000 Peak Deaths from cancer, along with $274 billion (1982 dollars) in property damage."[19]

In January of 2017, Governor Andrew Cuomo reversed the State's previous position and announced plans to close both of the Indian Point facilities. This sudden change of position was startling given the Governor's approval, a few months earlier, of millions of dollars in funding to prop up the State's aging nuclear plants.[20] Indian Point Unit 2 is scheduled to be shut down by April 2020 and Indian Point Unit 3 by April 2021.[21] In his statement regarding plans to shutter the reactors, the Governor cited safety reasons as a primary concern, asserting that "New York City sits 30 minutes from a ticking time bomb."[22] Over the past few years, Indian Point

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news/nation/2011-06-27-Nuclear-plants-population-evacuation_n.htm [hereinafter Populations around U.S. nuclear plants soar].

[17] *Id.*

[18] Karl S. Coplan, *The Intercivilizational Inequities of Nuclear Power Weighed Against the Intergenerational Inequities of Carbon Based Energy*, 17 FORDHAM ENVTL. L. REV. 227, 244 (2006).

[19] *Id.*

[20] *See* Andrew Siff, *Indian Point Nuclear Plant to Shut Down by 2021,* NBC N.Y. (updated Jan 6, 2017, 4:09 PM), http://www.nbcnewyork.com/news/local/Indian-Point-Nuclear-Plant-Shut-Down-2021-New-York-State-Deal-Entergy-409921775.html (stating that "The Indian Point nuclear plant in Westchester will shut down by 2021 under a deal reached between New York state and Entergy").

[21] *See Cuomo: Indian Point Nuclear Power Plant to Close by April 2021*, CBS N.Y. (Jan. 9, 2017, 5:00 PM) http://newyork.cbslocal.com/2017/01/09/indian-point-closing-cuomo/ (last visited Feb. 9, 2017) [hereinafter Indian Point Nuclear Power Plant to Close].

[22] *Id.*

had been the subject of a series of radiation leaks, fires and unplanned outages.[23] In February of 2016, there was an overflow at the plant that spilled highly radioactive water into an underground monitoring well.[24] And in October 2016, an undetermined amount of oil from the facility spilled into a drainage canal that leads into the Hudson River.[25] Entergy stated that the reason for the closure was the economic pressure facing the plant due to cheap natural gas, while declining to comment on the safety issues mentioned by Governor Cuomo.[26]

As of 2017, Indian Point and forty-five other nuclear reactors in the United States are at least forty-years old, and forty-three are at least thirty-years old, with the nation's oldest reactor

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[23] *See, e.g., Entergy Report: Insulation Failure Sparked Transformer Fire At Indian Point*, CBS N.Y. (June 30, 2015, 3:06 PM) http://newyork.cbslocal.com/2015/06/30/entergy-insulation-failure-fire-indian-point/ (reporting that a failure of insulation resulted in a transformer fire that shut down Indian Point nuclear power plant); *Control Rod Power Loss Spurs Indian Point Reactor Shutdown*, CBS N.Y. (Dec. 6, 2015, 10:16 AM) http://newyork.cbslocal.com/2015/12/06/control-rod-power-loss-spurs-indian-point-reactor-shutdown/ (last visited Feb. 25, 2017) (reporting an unexplained power outage at Indian Point); *Indian Point Plant Owner to Determine 'Precise' Cause of Latest Unit Shutdown*, CBS N.Y. (Dec. 15, 2015, 9:59 PM) http://newyork.cbslocal.com/2015/12/15/indian-point-plant-electrical-disturbance/ (reporting "an electrical disturbance prompted the shutdown of a generator and reactor at the Indian Point nuclear power plant"); *Hundreds of Faulty Bolts Found At Indian Point Nuclear Plant*, CBS N.Y. (March 29, 2016, 11:25 AM) http://newyork.cbslocal.com/2016/03/29/cuomo-indian-point-plant/ (reporting that "Hundreds of faulty bolts have been discovered at the Indian Point power plant," and that "some of the bolts on the reactor's inner liner were missing");

[24] *See Lawmakers Call for Probe After Indian Point Groundwater Contamination*, CBS N.Y. (Feb. 8, 2016, 5:21 PM) http://newyork.cbslocal.com/2016/02/08/indian-point-water-contamination-probe/ (reporting that "lawmakers are calling or a thorough investigation of a recent leak of radioactive material, which was found in the groundwater at Indian Point Energy Center").

[25] *See Clean-up Continues at Indian Point Nuclear Plant After Oil Spill*, CBS N.Y. (Oct. 1, 2016, 12:39 PM) http://newyork.cbslocal.com/2016/10/01/indian-point-power-plant-oil-spill/ (reporting clean-up efforts at the Indian Point Nuclear Plant after "state environmental officials were notified after an oil sheen was observed in the discharge canal").

[26] *See* Indian Point Nuclear Power Plant to Close, *supra* note 21 (quoting Entergy President Bill Mohl: "This decision was truly based on economics").

being built in 1969.[27] Analysis conducted by the Associated Press in 2010 determined that roughly four million people live within ten miles of the nation's sixty-five operating nuclear power sites, and estimated one hundred and twenty million people live within fifty miles of a nuclear plant.[28]

In the face of economic pressure from historically low natural gas prices, nuclear energy industry stakeholders have been accused of "greenwashing"[29] people into believing that nuclear energy is a clean and renewable energy source worthy of substantial government subsidization.[30] Nuclear energy companies argue that nuclear power is carbon-free and often a more economically viable response to global warming, than solar or wind energy, because of its non-intermittent nature.[31]

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[27] Intl. Atomic Energy Agency, *United States of America Country Statistics,* (updated Feb. 19, 2018) https://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=US [hereinafter US Statistics].

[28] *See* Populations around U.S. nuclear plants soar, *supra* note 16.

[29] Greenwashing occurs when a company advertises their product as being environmentally superior, even though the company has not invested in sustainability measures. *See generally* Karen Bradshaw-Shultz, *Information Flooding,* 48 IND. L. REV. 755, 765 (2015) ("Firms with poor environmental performance "greenwash" by advertising their products as being environmentally-superior, even when they have not made investments in sustainability measures. 'Greenwashing' is information flooding that involves materials related to the sustainability of products and companies. Firms engaged in greenwashing are intentionally overwhelming consumers with so information that consumers cannot determine whether a company or product meets their preferences for good environmental performance … [t]he worse a firm's environmental performance, the more information it releases, claiming good performance").

[30] *See generally* Anne Winslow, *A Nuclear Renaissance: The Role of Nuclear Power in Mitigating Climate Change*, 1342 AIP CONF. PROC. 127 (2011); Mariah Zebrowski, *Nuclear Power as Carbon-Free Energy? The Global Nuclear Energy Partnership*, 20 COLO. J. INT'L ENVTL. L. & POL'Y 391 (2009); Jeffrey H. Wood et al., *Moving Targets: Nuclear Power as A Component of EPA's Clean Power Plan*, 30 NAT. RESOURCES & ENV'T 40 (2016).

[31] *See* Zachary Robock, *Economic Solutions to Nuclear Energy's Financial Challenges*, 5 MICH. J. ENVTL. & ADMIN. L. 501, 504–06 (2016) (explaining that nuclear plants "have very low, very stable operating costs" and how nuclear energy "is the only carbon-free energy source capable of supplying reliable baseload electricity").

Why are nuclear energy stakeholders today pushing so hard to gain nuclear energy a "green" label equivalent to that of solar and wind energy? And how should policymakers respond to these arguments? This Article seeks to shine light on these questions by highlighting certain behavioral economics and basic microeconomic concepts that help explain the nation's growing infatuation with nuclear energy. This Article ultimately argues that policymakers should be cautious not to underestimate the risks and costs associated with nuclear power, as the world searches for means of addressing the growing threat of human-induced climate change.

This Article proceeds in five parts. Part I begins by briefly outlining the history of the rise and fall of the nation's nuclear energy industry, and how the industry reached its current state. Part II describes how global warming concerns are driving increases in the market demand for carbon-free energy production, and how this increasing demand partly explains today's nuclear energy renaissance. Part III examines the differing negative externality problems between nuclear, wind, and solar energy. Part III also proffers that wind and solar energy generation impose comparatively far fewer environmental and other costs while making the distinction that voters and other policy decision-makers do not bear many of nuclear energy's additional costs. Part IV outlines certain behavioral economic concepts and other theories that help to further explain why policymakers have become increasingly open to treating nuclear energy as a clean and renewable energy source. Part V offers a few specific policy proposals aimed at reversing this pernicious trend and at promoting the growth of conventional forms of renewable energy rather than nuclear energy.

I. BACKGROUND

Nuclear energy has long been a powerful, yet controversial, energy source. In its earliest days, it was envisioned as the energy strategy of the future, and the federal government provided generous incentives to facilitate the growth of the nuclear industry. As described below, this golden era of nuclear energy peaked after the Three Mile Island incident—the first and only nuclear incident on

American soil. After that accident, public acceptance of nuclear energy in the United States drastically declined. The negative sentiment against nuclear power has largely remained, due in part to additional nuclear disasters, such as Chernobyl and Fukushima.

A. The History of Nuclear Energy: Power and Promise

Nuclear energy's history has been marked by more dramatic ups and downs than perhaps any other major energy strategy. Uranium—the most common type of nuclear energy fuel—was first discovered in 1789.[32] Its capability as an energy source was not fully discovered until 1942, in the form of the world's first nuclear chain reaction as part of the wartime Manhattan Project.[33] Most of the early research associated with nuclear energy focused on developing an effective weapon for use in World War II.[34] The rest of the world was introduced to nuclear energy's explosive power in August of 1945, when the United States dropped atomic bombs on the Japanese cities of Hiroshima and Nagasaki.[35] The bombs' annihilating results "cast a fearsome shadow over the near era of peace and prosperity."[36] Even though most of the atomic research at that time was focused on

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[32] *See Outline History of Nuclear Energy,* WORLD NUCLEAR ASSOC. (updated Jan. 2018), http://www.world-nuclear.org/information-library/current-and-future-generation/outline-history-of-nuclear-energy.aspx.

[33] *Nuclear Power History: Timeline from Inception to Fukushima,* HUFFINGTON POST, (Updated Aug. 13, 2012) http://www.huffingtonpost.com/2012/06/13/timeline-nuclear-power-history-fukushima_n_1593278.html (stating that "[t]he world's first nuclear chain reaction takes place in Chicago as part of the wartime Manhattan Project") [hereinafter Nuclear Power History].

[34] *See* U.S. DEP'T OF ENERGY, THE HISTORY OF NUCLEAR ENERGY 8 (2000) https://www.energy.gov/sites/prod/files/The%20History%20of%20Nuclear%20Energy_0. (describing how "[i]n the years just before and during World War II, nuclear research focused mainly on the development of defense weapons") pdf [hereinafter DOE/NE-0088].

[35] JOEL B. EISEN ET AL., ENERGY, ECONOMICS AND THE ENVIRONMENT: CASES AND MATERIALS 396 (Robert C. Clark et al. eds., 4th ed. 2015); *see* Nuclear Power History, *supra* note 33.

[36] James Chater, *A History of Nuclear Power,* FOCUS ON NUCLEAR POWER GENERATION, 28, 29 (2004) http://www.nuclear-exchange.com/pdf/tp_history_nuclear.pdf.

building nuclear weapons, some scientists were focused on creating *breeder reactors,* which would eventually produce fission-able uranium material capable of sustaining an electrical charge.[37] After the war ended, the United States government encouraged the "development of nuclear energy for peaceful civilian purposes" and in 1946, Congress created the Atomic Energy Commission (AEC).[38] The original objective of the AEC was the promotion and regulation of nuclear power.[39]

On December 20, 1951, 162 years after uranium was first discovered, an experimental "breeder" reactor in Idaho powered four light bulbs and demonstrated to the world that nuclear power was a potentially viable means of electricity generation.[40] In an effort to create reactors to power the United States Navy, Admiral Hyman Rickover's blueprints are often credited with establishing the design for the first commercial nuclear power plant, which came online in 1957, in Shippingport, Pennsylvania.[41]

1. How Nuclear Energy Works

Similar to oil, coal, and other gas-fired generation, nuclear power uses steam to rotate turbines that generate electricity.[42] As stated above, nuclear energy is primarily supplied through uranium.

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[37] *See* DOE/NE-0088, *supra* note 34, at 8 (describing how "some scientists worked on making *breeder reactors,* which would produce fission-able material in the chain reaction").

[38] *Id.*

[39] *See* Chater, *supra* note 36, at 30 (describing how "the USA set up the Atomic Energy Commission in 1946 with the purpose of both promoting and regulating nuclear power").

[40] *See* DOE/NE-0088, *supra* note 34, at 8 (stating "[t]he Experimental Breeder Reactor I generated electricity to light four 200-watt bulbs on December 20, 1951. This milestone symbolized the beginning of the nuclear power industry").

[41] *See* EISEN, *supra* note 35, at 400 (describing how "Despite competition over reactor designs in the private sector, Admiral Hyman Rickover's efforts to design reactors to power the American Navy are credited with yielding the design of the first U.S. commercial nuclear power plant, which came on line in 1957 in Shippingport, PA, near Pittsburgh").

[42] *See id.* at 398 (describing the process of how nuclear power plants generate steam to turn turbines which generate electricity).

In 2012, about 83 percent of the uranium consumed in United States came from mines in other countries, with only a few domestic mining facilities in America that contributed the remaining uranium.[43] After the uranium is processed, it is converted into ceramic pellets.[44] These pellets are then loaded into fuel rods that are placed into the reactor.[45] Nuclear fission is created in a "chain reaction" in the nuclear power plants' reactor core.[46] The chain reaction generates heat, which converts water into pressurized steam that drives a turbine and generates electricity.[47] The steam that is used to spin the turbines is then cooled off to be reused.[48] Light-water reactors, like the Shippingport reactor, use ordinary water to cool the

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[43] *See The U.S. relies on foreign uranium, enrichment services to fuel its nuclear power plants*, U.S. ENERGY INFO. ADMIN. (Aug. 28, 2013), http://www.eia.gov/todayinenergy/detail.php?id=12731 (portraying a pie chart describing the percentage of "uranium purchased by owners and operators of U.S. commercial nuclear reactors" in 2012: Canada, 24 percent; United States, 17 percent; Russia, 13 percentage; Australia, 12 percentage; Kazakhstan, 11 percentage; Namibia, 10 percentage; Uzbekistan, 4 percentage; Niger, 4 percentage; Brazil, China, Malawi, Ukraine, 3 percentage; South Africa, 2 percentage).

[44] *See How Nuclear Reactors Work*, NUCLEAR ENERGY INST., https://www.nei.org/Knowledge-Center/How-Nuclear-Reactors-Work (explaining that nuclear plants "use uranium fuel, consisting of solid ceramic pellets").

[45] *See id.* (stating "uranium fuel consists of small, hard ceramic pellets that are packaged into long, vertical tubes. Bundles of this fuel are inserted into the reactor").

[46] *See* EISEN, *supra* note 35, at 399 (stating that "At the heart of commercial nuclear power plants in the United States are reactor vessels, which house the fuel assemblies and in which nuclear fission takes place in a chain reaction").

[47] *See* JOSEPH P. TOMAIN & RICHARD D. CUDAHY, ENERGY LAW IN A NUTSHELL 447–48 (2d ed. 2011) (describing how "Fission is a chain reaction which splits an enriched uranium nuclear and results in the release of energy (heat)," "Nuclear reactors are in effect large expensive tea kettles that heat water to generate electricity," "the reactor core creates heat and pressurized water carries that heat to the steam generator where the pressurized water is vaporized to drive the turbine; then the vapor is released").

[48] *See How Nuclear Power Works*, UNION OF CONCERNED SCIENTISTS http://www.ucsusa.org/nuclear-power/nuclear-power-technology/how-nuclear-power-works#.WLJarRCZS34 (revised Jan. 29, 2014) [hereinafter How Nuclear Power Works] (explaining how "after steam is used to power the turbine, it is cooled off to make it condense back into water").

reactor core during the chain reaction,[49] while other plants use water from lakes, rivers, or the ocean.[50] Cooling towers, a notable and prominent feature of nuclear power plants, help to condense steam back into water for reuse.[51]

2. The Creation of the Nuclear Regulatory Commission

Originally, responsibility for the oversight of nuclear technologies was vested in the Manhattan Engineer District of the United States Army Corp of Engineers.[52] This responsibility was assigned to the AEC after it was created by Congress in 1946.[53] The AEC was the predecessor to both the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE).[54] The AEC was tasked with broad authority over the entire nuclear industry, which included developing nuclear energy, regulating its safety, and creating the nation's nuclear weapons arsenal.[55] The primary policy function of the AEC was to encourage the private industry to construct nuclear power plants and facilitate the emergence of nuclear energy.[56]

In the years immediately following World War II, the United States was the only nation that had demonstrated the ability to create nuclear fission.[57] The federal government hoped that it could

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[49] *See* DOE/NE-0088, *supra* note 34, at 8.

[50] *See* How Nuclear Power Works, *supra* note 48 (stating that nuclear power plants also "use water from rivers, lakes or the ocean to cool the steam, while others use tall cooling towers").

[51] *See* EISEN, *supra* note 35, at 399.

[52] *Id.*

[53] TOMAIN & CUDAHY, *supra* note 47, at 450 (explaining that "The chief functions of the AEC were to encourage research and promote development of the technology for peaceful purposes").

[54] *See generally* Energy Reorganization Act of 1974, 42 U.S.C. § 5801 (2012) (the Energy Reorganization Act of 1974 established the Nuclear Regulatory Commission and the Energy Research and Development Administration which was later transformed into the U.S. Department of Energy in 1977).

[55] *See, e.g.*, ALICE BUCK, U.S. DEP'T OF ENERGY, THE ATOMIC ENERGY COMMISSION (1983), https://energy.gov/sites/prod/files/AEC%20History.pdf.

[56] *Id* at 13.

[57] *See* EISEN, *supra* note 35, at 397.

maintain that monopoly, but it soon became apparent that the Soviet Union was also capable of producing nuclear weapons.[58] In 1953, President Eisenhower addressed the United Nations, in his "Atoms for Peace" speech, calling for international cooperation in the development of nuclear technology for peaceful purposes.[59] This initiative was meant to deter nuclear weapons proliferation in exchange for sharing information worldwide.[60]

A major goal of nuclear research in the mid-1950s was to show that nuclear energy could produce electricity for commercial use.[61] Lewis Strauss, an original Atomic Energy Commissioner, is most notably remembered for his view and coined phrase of nuclear energy—"too cheap to meter."[62] In his 1954 address to science writers, Strauss stated:

> It is not too much to expect that our children will enjoy in their homes electrical energy too cheap to meter,—will know of great periodic regional famines in the world only as matters of history,—will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds,—and will experience a lifespan far longer than ours, as disease yields and man comes to under-

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[58] J. SAMUEL WALKER & THOMAS R. WELLOCK, U.S. NUCLEAR REGULATORY COMM'N, A SHORT HISTORY OF NUCLEAR REGULATION, 1949–2009, 3 (2010).

[59] *See* David S. Jonas, *The New U.S. Approach to the Fissile Material Cutoff Treaty: Will Deletion of a Verification Regime Provide a Way Out of the Wilderness?*, 18 FLA. J. INT'L L. 597, 606 (2006) (stating the goals of Eisenhower's speech was "to advance the peaceful uses of atomic energy along with nuclear disarmament by transferring fissile material from military to civilian uses").

[60] *See* Helen M. Cousineau, *The Nuclear Non-Proliferation Treaty and Global Non-Proliferation Regime: A U.S. Policy Agenda*, 12 B.U. INT'L L.J. 407, 411 (1994).

[61] *See* DOE/NE-0088, *supra* note 34, at 8.

[62] DAVID BODANSKY, NUCLEAR ENERGY: PRINCIPLES, PRACTICES, AND PROSPECTS 32 (2d ed. 2004) (quoting Lewis L. Strauss's speech in 1954 as Chairman of the U.S. Atomic Energy Commission).

stand what causes him to age. This is the forecast for
an age of peace.[63]

Strauss expected that his children and grandchildren would have power "too cheap to be metered, just as we have water today that's too cheap to be metered."[64] From 1954 forward, the AEC could license private companies to build and operate nuclear power plants.

During the 1950s and 1960s, the AEC knew that serious accidents would have immense radiological consequences but assumed that, with adequate engineering precautions, they could be prevented with a very high degree of assurance.[65] In 1957, the AEC developed a report that made estimates of what would happen if the contents of a power reactor core were released in a way analogous to a nuclear weapon.[66] The report predicted that 3,400 people would die of radiation exposure, 43,000 would be injured, there would be a possible need to evacuate the population from an area of up to 8,200 square miles and as much as 150,000 square miles of land would be placed under agricultural restrictions due to long-lived radioactive contamination.[67] In an effort to forestall such outcomes, the AEC decided not to publish the report because they believed "it would be misunderstood."[68] The AEC, confident that no serious accident would ever occur, did not require reactor operators or local

[63] Thomas Wellock, *"Too Cheap to Meter": A History of the Phrase,* U.S. NUCLEAR REGULATORY COMM'N (June 3, 2016), https://public-blog.nrc-gateway.gov/2016/06/03/too-cheap-to-meter-a-history-of-the-phrase/.
[64] *Id.*
[65] *See* Geist, *supra* note 12.
[66] U.S. ATOMIC ENERGY COMM'N, THEORETICAL POSSIBILITIES AND CONSEQUENCES OF MAJOR ACCIDENTS IN LARGE NUCLEAR POWER PLANTS (1957), *available at* https://babel.hathitrust.org/cgi/pt?id=mdp.39015095068097;view=1up;seq=27.
[67] *Id.* at 13-14.
[68] Richard Sieg, *A Call to Minimize the Use of Nuclear Power in the Twenty-First Century*, 9 VT. J. ENVTL. L. 305, 351 (2008) (the author notes that the report was obtained by a FOIA request by the Union of Concerned Scientists in 1973).

governments, during the 1960s and early 1970s, to plan for a nuclear accident with off-site consequences.[69]

During this golden era for nuclear power, nuclear energy was widely deemed to be the power strategy of the future.[70] In 1960, the Atomic Energy Commission estimated that the nation would be powered by thousands of nuclear reactors by the year 2000.[71] The nuclear power industry in the United States grew rapidly during the 1960s.[72] Utility companies saw this new form of electricity production as economical, environmentally clean, and safe.[73] Public reaction to nuclear power was initially positive, dominated by patriotic pride in American technology, suppressing fears about accidental or hostile misuse of power.[74] However, as the public became aware of the long-range impacts of radiation sickness on the residents of Hiroshima and Nagasaki, the fear of nuclear power began to spread.[75]

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[69] *See* Richard. T. Sylves, *Nuclear Power Plants and Emergency Planning: An Intergovernmental Nightmare*, 44 PUB. ADMIN. REV. 393, 394 (1984) (stating "[m]any histories of U.S. civilian nuclear power reflect government and nuclear industry confidence that the many safeguards and redundancies built into nuclear power plants would make the possibility of an accident with off-site consequences astronomically low … national policy makers were not seriously concerned that a need existed to plan for off-site accident contingencies … nuclear power emergency response planning was only interesting to national policy makers when it was topical. Until [Three Mile Accident], nuclear regulatory authorities were largely indifferent about the need to develop sound and operational emergency plans for off-site areas. Nuclear utility executives seemed to share this indifference").

[70] *See* Charles de Saillan, *Disposal of Spent Nuclear Fuel in The United States and Europe: A Persistent Environmental Problem*, 34 HARV. ENVTL. L. REV. 461, 465-66 (2010) ("At its inception, proponents of nuclear power … predicted a utopian society powered by fleets of atomic plants providing clean, cheap, and abundant energy, electricity that would be 'too cheap to meter'").

[71] Daniel Mcglynn, *The future of nuclear energy,* PHYS.ORG (Nov. 28, 2016), https://phys.org/news/2016-11-future-nuclear-energy.html.

[72] *See* US Statistics, *supra* note 27 (providing statistical data that states twenty nuclear plants came on line between 1960 and 1969).

[73] *Id.*

[74] *See* EISEN, *supra* note 35, at 400.

[75] *See id.*

A major oil embargo and its upward pressure on the price of oil drove an even greater interest in nuclear energy in the early 1970s. The oil embargo of 1973, and the subsequent quadrupling of oil prices, inspired the United States, Europe and Japan to search for alternatives to petroleum.[76] As a result, the use of liquid petroleum as a source of power generation was phased out in the United States, in favor of an increased reliance on nuclear power.[77] Shortly thereafter, Congress enacted the Energy Reorganization Act of 1974, which abolished the AEC and created three successor agencies: the Nuclear Regulatory Commission, which was tasked with licensing and regulation of nuclear power plants; the Energy Research and Development Administration (ERDA), which was tasked with research development and production of nuclear energy; and the Federal Energy Administration (FEA), which was tasked with data collection and analysis of nuclear energy.[78] The ERDA and FEA were later combined in 1977 to become the DOE. The NRC became responsible for regulating the "commercial, industrial, academic and medical uses of nuclear materials and nuclear energy."[79]

As the nuclear industry grew, government officials strived to implement new regulation that ensured adequate safety precautions. In 1978, the NRC and the EPA agreed on the concept of "emergency planning zones," which remains a prominent feature of the United States plan to ameliorate the consequences of reactor accidents.[80] The agencies recommended two zone sizes in anticipation of numerous different radiation hazards: one with a radius of ten miles to address whole-body radiation exposure, and another with a radius of fifty miles aimed at preventing ingestion of radioactivity in

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[76] *See* Jeannette M. Nishimura-Paige, *Pacific Gas & Electric: A Nuclear Energy Option or a Nuclear Energy Mandate?*, 35 SYRACUSE L. REV. 995, 997 (1984).

[77] *See* Scott F. Bertschi, *Integrated Resource Planning and Demand-Side Management in Electric Utility Regulation: Public Utility Panacea or a Waste of Energy?*, 43 EMORY L. J. 815, 825 (1994).

[78] *See* 48 U.S.C § 5801, *supra* note 54.

[79] U.S. NUCLEAR REG. COMM'N, CITIZEN'S GUIDE TO U.S. NUCLEAR REGULATORY COMMISSION INFORMATION (Rev. 4, 2003).

[80] Geist, *supra* note 12.

food and water.[81] The NRC and EPA concluded that an accident creating radiation hazards dire enough to require evacuation of more than ten miles from a plant were extremely unlikely, and recommended that relocation plans only address the ten mile zone.[82]

Between 1973 and the early 1990s, nuclear energy's share of the United States' electricity generation increased from 4 percent to 20 percent, while oil's share dropped from 17 percent to 4 percent.[83] Despite this increase in production share, in the 1970s and 1980s growth of the domestic nuclear power industry slowed.[84] The demand growth for nuclear-generated electricity decelerated and concern grew over nuclear issues, such as reactor safety, waste disposal and other environmental considerations.[85] Nonetheless, the United States had twice as many operating nuclear power plants as any other country in 1991.[86] This was still more than one-fourth of the world's operating plants.[87] Nuclear energy supplied almost 22 percent of the electricity produced in the United States.[88]

3. Prior Subsidization of Nuclear Energy

To give nuclear energy a fighting chance in a market dominated by fossil-fuels, the government created incentives for the private construction of nuclear facilities in the form of subsidies. For many years, the United States government has subsidized utility

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[81] *See* Emergency Planning, 45 Fed. Reg. 55,402, 55,406 (Aug. 19, 1980) (codified at 10 C.F.R. part 50).

[82] *See* Donald J. Zeigler & James H. Johnson, *Evacuation Behavior in Response to Nuclear Power Plant Accidents*, 36 PROF. GEOGRAPHER, 207, 207 (1984).

[83] Chater, *supra* note 36, at 33.

[84] *See* DOE/NE-0088, *supra* note 34, at 9.

[85] *See* Diane Carter Maleson, *The Historical Roots of the Legal System's Response to Nuclear* Power, 55 S. CAL. L. REV. 597, 616 (1982).

[86] *See* Mustafa Balat, *The role of nuclear power in global electricity generation*, 2 ENERGY SOURCES, B 381 (2007).

[87] L. C. Okoro et al. *Nuclear Energy; a Review of the Technology, Applications, and Environmental Problems*, 2 IIARD INT'L J. GEOGRAPHY & ENVTL. MGMT. 1, 6-7 (2016).

[88] *See* DOE/NE-0088, *supra* note 34, at 9.

companies that generate electricity.[89] Subsidies have existed since the earliest stages of the energy industry in the United States. Generally, the federal government heavily subsidizes emerging markets, such as nuclear and renewable energy, to incentivize utility companies to invest in them. As the new entrants to the market mature, the subsidies supporting their initial foray into the marketplace tend to decrease. For the fiscal year of 2013, nuclear energy companies received roughly 10 percent of the total amount of subsidies given to the energy industry.[90]

One of the oldest subsidies that nuclear energy facilities can receive from the federal government falls under the Price-Anderson Act of 1957.[91] The Price-Anderson Act creates a system of reparation between the nuclear energy facilities and the federal government.[92] If a nuclear accident were to happen, under the Price-Anderson Act, the nuclear energy facility would be required to cover the costs up to a statutorily defined limit, and the federal government would cover the remaining costs.[93]

Congress added an additional subsidy program for the nuclear energy industry in Section 1306 of the Energy Policy Act of 2005. Section 1306 creates production tax credits for advanced nuclear facilities, which "provide developers with a more consistent cash flow" that protects against the unpredictable price fluctuations of the energy market.[94] This subsidy supports the expansion of

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[89] *See generally* William K. Krueger, Jr., *Nuclear vs. Big Solar: Government Funding of 21st Century Energy Production*, 10 N.C. J.L. & TECH. 49, 49 (2008) (stating "The government incentivizes investment in carbon-free energy production facilities by creating tax schemes designed to make renewable energy more attractive for investors" and citing various nuclear tax incentives).

[90] *See* U.S. ENERGY INFO. ADMIN., DIRECT FEDERAL FINANCIAL INTERVENTIONS AND SUBSIDIES IN ENERGY IN FISCAL YEAR 2013, xix (2015), http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.

[91] The Price-Anderson Act of 1957 was later codified as 42 U.S.C. § 2210. *See* Krueger, *supra* note 89, at 50 (highlighting how "Nuclear energy facilities receive much aid from the government in a variety of forms, one of the oldest of which is the Price-Anderson Act of 1957, codified as 42 U.S.C § 2210").

[92] *See generally* 42 U.S.C. § 2210 (2012).

[93] *See id.*

[94] Seth P. Cox, *The Nuclear Option: Promotion of Advanced Nuclear Generation as a Matter of Public Policy*, 5 APPALACHIAN NAT. RES. L.J. 25, 56 (2010-2011)

nuclear energy, and as a result, incentivizes research and development of new nuclear technology.[95] These subsidies can encourage the competitiveness of nuclear energy against other energy sources, and are often seen as an essential tool to promote nuclear energy.[96]

4. Early Nuclear Accidents and the First Meltdown of Support

After the nuclear incident at Three Mile Island in 1979, the golden era of nuclear energy development abruptly ended. Globally, there are three notable nuclear incidents on record: Three Mile Island, Chernobyl, and Fukushima. On March 28, 1979, a partial core meltdown occurred at the Three Mile Island facility.[97] The incident at Three Mile Island highlighted both the lack of crisis management from the NRC and the inherent weaknesses within the federal government's emergency management system generally.[98] Three Mile Island exposed the absence of an evacuation plan and a general lack of training on how to handle emergency situations at the plant.[99] Fortunately, despite significant damage to the reactor,

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(describing that "Section 1306 of the EPAct 2005 provides credit for production from advanced nuclear facilities. Eligible facilities may receive a subsidy of 1.8¢ per kWh, up to an aggregate national installed capacity of 6,000 MW of generation. The tax credits provide developers with a more consistent cash flow, buffering against unpredictable price fluctuations").

[95] *See* Lynne Holt et al., *(When) to Build or Not to Build?: The Role of Uncertainty in Nuclear Power Expansion*, 3 TEX. J. OIL GAS & ENERGY L. 174, 207 (2008).

[96] *See* Cox, *supra* note 94, at 56 (observing how "production tax credits enhance the competitiveness of advanced nuclear, and are therefore another essential tool to promotion of nuclear energy as a matter of policy").

[97] *See* Joseph P. Tomain & Constance Dowd Burton, *Nuclear Transition: From Three Mile Island to Chernobyl*, 28 WM. & MARY L. REV. 363, 364 (1987) (describing the accident at Three Mile Island).

[98] Geist, *supra* note 12 (noting the lack of emergency planning and crisis management).

[99] Hope M. Babcock, *A Risky Business: Generation of Nuclear Power and Deepwater Drilling for Offshore Oil and Gas*, 37 COLUM. J. ENVTL. L. 63, 107–08 (2012) (explaining a lack of planning and weaknesses in preparedness for an accident at Three Mile Island).

most of the radiation remained contained.[100] Three Mile Island illustrated the necessity of enhanced planning, emergency response, and communication between the various levels of government on how to best handle nuclear reactor emergencies.[101] Federal oversight for emergency preparedness is now shared jointly by the NRC and the Federal Emergency Management Agency (FEMA).[102]

On April 26, 1986, a nuclear reactor at the Chernobyl plant in Ukraine, then the U.S.S.R., exploded.[103] The explosion, coupled with the resulting fire, immediately released radiation into the air.[104] Like the Three Mile Island accident, the Soviet government had neither evacuation plans nor any way to gauge the amount of radioactive material escaping from the damaged reactor.[105]

Twenty-five years after Chernobyl, on March 11, 2011, an earthquake and subsequent tsunami hit the Fukushima Daiichi nuclear plant.[106] The tsunami destroyed Fukushima's primary seawater-pump cooling system and backup power sources, causing the plant to lose power. As a result, reactors one through four were

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[100] *See* Barry Kellman, *Anxiety over the Tmi Accident: An Essay on Nepa's Limits of Inquiry*, 51 GEO. WASH. L. REV. 219, 231 (1982–1983) (describing the minimal release of radiation despite serious damage to the nuclear plant).

[101] U.S. NUCLEAR REGULATORY COMM'N, EMERGENCY PREPAREDNESS AT NUCLEAR POWER PLANTS, 1 (2014), https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/emerg-plan-prep-nuc-power.pdf (observing the addition of FEMA to emergency preparedness oversight).

[102] *Id.*

[103] *See generally* Justin Mellor, *The Negative Effects of Chernobyl on International Environmental Law: The Creation of the Polluter Gets Paid Principle*, 17 WIS. INT'L L.J. 65 (1999) (describing the Chernobyl accident).

[104] *See* Kim Hjelmgaard, *Chernobyl: Timeline of a Nuclear Nightmare,* USA TODAY (Apr. 16, 2016), http://usat.ly/1NgtchV (explaining the timeline of events of the Chernobyl disaster).

[105] Geist, *supra* note 12.

[106] *See* Ellen O'Grady, *U.S. NRC to Issue First Post-Fukushima Safety Rules,* REUTERS (Mar. 1, 2012, 7:38 PM), http://reut.rs/xMUJfi ("As the first anniversary of Japan's Fukushima nuclear disaster approaches, U.S. nuclear regulators have moved to issue the first new rules to deal with safety issues raised by the world's worst nuclear accident in 25 years, according to agency filings. On March 11, 2011, an earthquake and tsunami overwhelmed the Fukushima Daiichi plant on Japan's northeast coast, knocking out critical power supplies that resulted in a nuclear meltdown and the release of radiation").

unable to be cooled, leading to meltdowns in reactors one through three.[107] A month after the earthquake and tsunami, Japan put the severity of the crisis at Fukushima Daiichi at seven, the maximum severity level, placing the Fukushima Daiichi disaster on par with Chernobyl.[108]

5. Prior Policy Efforts to Pull Back from Nuclear Energy

The growth and decline cycles of nuclear power in the United States are perhaps most easily attributable to fluctuations in public support for nuclear energy over the past several decades.[109] Early atmospheric tests of U.S. nuclear weapons contaminated the Marshall Islands and further enhanced the public's perception of the dangers associated with nuclear weapons.[110] Initial concerns began in the 1960s, regarding the environmental impacts of nuclear power.[111] By the mid-70s, concerns about nuclear power transitioned into anti-nuclear activism.[112] The Three Mile Island incident resulted in public

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[107] *See* Phillip Y. Lipscy et al., *The Fukushima Disaster and Japan's Nuclear Plant Vulnerability in Comparative Perspective,* 47 ENVTL. SCI. & TECH. 6082, 6083 (2013), (describing what caused the reactors to meltdown at Fukushima Daiichi).

[108] *See Japan Raises Nuclear Crisis Severity to Highest Level,* REUTERS (April 11, 2011, 10:14 PM), http://www.reuters.com/article/japan-severity-idUSTKE00635720110412 (providing information that outlined the severity of the Fukushima disaster).

[109] *See* Jonathan Melville, *The Decline and Death of Nuclear Power*, 17 BERKELEY SCI. J. 1, 2 (2013) (observing that public sentiment is the most powerful force that dictates the growth or decline of nuclear power).

[110] *See* Winston P. Nagan & Erin K. Slemmens, *National Security Policy and Ratification of the Comprehensive Test Ban Treaty*, 32 HOUS. J. INT'L L. 1, 13 (2009) (noting the testing of nuclear weapons, by the United States, in the Marshall Islands).

[111] *See* Sheldon L. Trubatch, *How, Why, and When the U.S. Supreme Court Supports Nuclear Power*, 3 ARIZ. J. ENVTL. L. & POL'Y 1, 9 (2012) (describing how the public's concerns began to focus on the environmental impacts of nuclear power).

[112] *See generally* Matthew Lippman, *Civil Resistance: The Dictates of Conscience and International Law Versus the American Judiciary*, 6 FLA. J. INT'L L. 5, 36, 37 (1990), (explaining the anti-nuclear movement of the 1970s and 1980s that saw a

backlash against the nuclear power industry and many plants that had been approved were cancelled.[113] Following the Three Mile Island incident, public opinion polls indicated the people who supported nuclear power, or were previously undecided, declined immediately, while the number opposed to nuclear power increased.[114] A significant part of the public sentiment against nuclear power stems from its association with nuclear weapons and the industry essentially hit bottom during the height of the Cold War due to the fear of nuclear conflict.[115]

After the Three Mile Island disaster, the nuclear industry continued its attempts to influence public sentiment in favor of nuclear energy by attempting to portray the incident as evidence of how safe nuclear power was.[116] Regardless, the public's trust in the safety of nuclear power continued to wane, and one factor was the lengthy delay between the accident and the release of information to the public.[117] Ultimately, the nuclear industry's efforts were ineffective as support for nuclear power declined drastically after Three Mile Island.[118] The accident fueled the global anti-nuclear

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resurgence in civil disobedience. These acts of protest focused on issues like nuclear power plants).

[113] *See* The Learning Network, *March 28, 1979 Nuclear Accident Occurs at Three Mile Island Plant,* N.Y. TIMES (Mar. 28, 2012, 4:02 AM) https://learning.blogs.nytimes.com/2012/03/28/march-28-1979-nuclear-accident-occurs-at-three-mile-island-plant/ (describing public sentiment toward nuclear power after Three Mile Island).

[114] *See* U.S. CONGRESS, OFFICE OF TECHNOLOGY ASSESSMENT, NUCLEAR POWER IN AN AGE OF UNCERTAINTY 16, 26 (Feb. 1984), https://www.princeton.edu/~ota/disk3/1984/8421/8421.PDF (illustrating the change in public opinion of those who were either for or unsure about nuclear power prior to Three Mile Island, to being against nuclear power after the accident).

[115] *See* Melville *supra* note 109, at 2.

[116] *See id.*

[117] *See* NUCLEAR ENERGY AGENCY ORG. FOR ECON. CO-OPERATION AND DEV., PUBLIC ATTITUDES TO NUCLEAR POWER, 45 (2010), https://www.oecd-nea.org/ndd/reports/2010/nea6859-public-attitudes.pdf (describing how the delay in the release of information on the accident at Three Mile Island to the public was a significant factor in the public's trust of the nuclear industry after the accident).

[118] *See* Daniel A. Dorfman, *The Changing Perspectives of U.S. and Japanese Nuclear Energy Policies in the Aftermath of the Fukushima Daiichi Disaster*, 30 PACE ENVTL. L. REV. 255, 264 (2012).

sentiment, and this had a tremendous impact on the politics of nuclear power.[119] The accident resulted in a moratorium on any additional nuclear power development, with the federal government and all fifty states refusing to approve any new construction.[120]

II. GLOBAL WARMING AND THE GROWING DEMAND FOR CARBON-FREE ENERGY

A major reason that nuclear power is drawing growing interest today stems from mounting concerns about human-induced global warming. Unprecedented global warming is widely believed to be occurring because of human activities that are releasing large quantities of carbon dioxide and other heat-trapping gas emissions into the air.[121] Once in the atmosphere, these gases act as a blanket, trapping heat and warming the planet.[122] Although a vocal minority insists otherwise, it is generally accepted within the global scientific community that the primary cause of global warming is the burning of fossil fuels for electricity production and transportation.[123] Currently, the combustion of fossil fuel generates 69 percent of the

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[119] *See id.*

[120] *See* Bentley Mitchell, *Diffusing the Problem: How Adopting a Policy to Safely Store America's Nuclear Waste May Help Combat Climate Change*, 28 J. LAND RESOURCES & ENVTL. L. 375, 383 (2008) (observing how the nuclear power industry was halted due to the Three Mile Island accident).

[121] *See Global Warming 101*, UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/global_warming/global_warming_101#.WIFT7JKZS35 (last visited Feb. 12, 2017) (hereinafter Global Warming 101, describing "The primary cause of global warming is human activity, most significantly the burning of fossil fuels to drive cars, generate electricity, and operate our homes and businesses").

[122] *See* V. Ramanathan & Y. Feng, *Air pollution, greenhouse gases and climate change: global and regional perspectives*, 43 ATMOSPHERIC ENV'T 37, 38 (2009) (comparing how a blanket keeps the body warm by trapping body heat to how CO_2 traps heat in the atmosphere).

[123] *See* Jet Propulsion Lab., *Scientific consensus: Earth's climate is warming*, NASA, (2017) https://climate.nasa.gov/scientific-consensus/ (last updated Oct. 3, 2017) (stating "Multiple studies published in peer-reviewed scientific journals how that 97 percent or more of actively publishing climate scientists agree: Climate-warming trends over the past century are extremely likely due to human activities").

world's electricity.[124] Due to population growth and a higher standard of living in developing countries, global demand for electricity is increasing twice as fast as overall energy use and is predicted to increase 78 percent by 2035.[125]

A. Pressure to Reduce Greenhouse Gas Emissions

To adequately address the issue of global warming, the world must significantly reduce the amount of heat-trapping emissions it emits into the air.[126] Global emissions of carbon dioxide from fossil fuel combustion have significantly increased since 1900.[127] Since 1970, carbon dioxide emissions have escalated by "90 percent, with emissions from fossil fuel combustion and industrial processes contributing about 97 percent of the total greenhouse gas emissions increase from 1970 to 2011."[128] The second largest contributor to greenhouse gas emissions has been agriculture, deforestation and other land-use changes.[129] Carbon dioxide accounts for "nearly three-quarters of the global greenhouse gas emissions and 82 percent of the United States' greenhouse gas emissions."[130]

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[124] *See* Anne Winslow, *A Nuclear Renaissance: The Role of Nuclear Power in Mitigating Climate Change*, 1342 AIP CONF. PROC. 1, 3 (2011).
[125] *Id.*
[126] *See Global Warming 101*, *supra* note 121.
[127] *See Global Greenhouse Gas Emissions Data*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data (last visited Feb. 23, 2017).
[128] *Id.*
[129] *See Summary for Policy Makers, in* CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE, IPCC, 1, 7, (2014), https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf (reporting that 24 percent of greenhouse gas emissions came from Agriculture, Forestry and Other Land Use (AFOLU). This emissions data includes "land based CO2 emissions from forest fires, peat fires and peat decay that approximate to net CO2 flux from the Forestry and Other Land Use (FOLU) sub-sector.").
[130] *See* U.S. ENVTL. PRO. AGENCY, OVERVIEW OF THE CLEAN POWER PLAN: CUTTING CARBON POLLUTION FROM POWER PLANTS, https://archive.epa.gov/epa/sites/production/files/2015-08/documents/fs-cpp-overview.pdf (last visited Feb. 26, 2017).

Unless mitigated, climate change consequences are predicted to severely impact nations across the globe. From stronger storms, to longer droughts, to increased insurance premiums, to higher food prices and longer allergy seasons, climate change has already begun destabilizing systems that society has long taken for granted.[131] Global climate change has already begun to threaten ecosystems as well.[132] Glaciers have shrunk, ice on rivers and lakes are breaking up earlier, plant and animal ranges have shifted, heat waves are more severe, and trees are flowering sooner.[133] Scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to greenhouse gases produced by human activities.[134]

One of the most readily observable effects of climate change has been the rapid melting of the polar ice caps. NASA predicts that sea levels will rise one to four feet by 2100.[135] Rising sea levels can cause permanent changes to landscapes when it inundates low-lying land.[136] In the United States, the Atlantic coast is especially vulnerable due to low elevations and sinking shorelines. The loss of coastal land in these areas will affect an extensive amount of people.[137] Nearly ten million people live in a coastal floodplain.[138]

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[131] *See id.*

[132] *See The Consequences of Climate Change*, NASA, http://climate.nasa.gov/effects/ (last updated Oct. 17, 2017) [hereinafter Consequences of Climate Change].

[133] *See generally* THOMAS R. KARL, GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, 27 (2009) (outlining the specific impacts that climate change will have on United States).

[134] *See* Consequences of Climate Change, *supra* note 132.

[135] *Id.*

[136] *See A Closer Look: Land Loss Along the Atlantic Coast*, U.S. ENVTL. PRO. AGENCY, https://www.epa.gov/climate-indicators/atlantic-coast (last visited Feb. 24, 2017).

[137] *Id.*

[138] Mark Crowell et al., *An estimate of the U.S. population living in 100-year coastal flood hazard areas*, 26 J. COASTAL RES. 201, 207, 209 (2010) ("The data show that for the United States and its territories (with a total permanent resident population of about 285,620,000, according to the 2000 U.S. census), approximately 8,651,000 people (3.0%) live in areas subject to the 1% annual chance (100 y) coastal flood hazard." However, the authors also note that the

Rising sea levels are a problem for coastal states that are either below sea level or just above it. The state of Louisiana, at its highest point, sits only 535 feet above sea level.[139] Because of this, every year, roughly twenty-five to thirty-five square miles of land off the coast are submerged under water.[140] Since the 1930s, Louisiana's coastline has lost 1,900 square miles of land.[141] Rising sea levels also threaten coastal and ocean activities, such as marine transportation of goods, offshore energy drilling, resource extraction, fish cultivation, recreation, and tourism.[142] These activities are a vital source to the nation's economy, generating roughly 58 percent of the national gross domestic product.[143]

In 1997, in an effort to agree upon a global solution to carbon dioxide emissions, the United Nations held a climate change convention in Kyoto, Japan.[144] The treaty that came out of that meeting, the Kyoto Protocol, called for developed nations to reduce their carbon dioxide emissions by 8 percent below 1990 emissions levels by the year 2012.[145] The protocols were ratified in 1997, and

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"8.6% population figure determined in this paper may be more appropriate if the goal is to determine the percent population living in or near areas subject to coastal flooding or perhaps erosion or some other nearshore process." This 8.6% equates to 24,662,000 people).

139 *See Louisiana Topographic Map*, GEOLOGY, https://geology.com/topographic-physical-map/louisiana.shtml (last visited Dec. 27, 2017).

140 *See* Caitlyn Kennedy, *Underwater: Land Loss in Coastal Louisiana Since 1932*, NAT'L OCEANIC AND ATMOSPHERIC ADMIN., (Apr. 5, 2013), https://www.climate.gov/news-features/featured-images/underwater-land-loss-coastal-louisiana-1932.

141 *Id.*

142 *See Climate Impacts on Coastal Areas*, ENVTL. PROT. AGENCY, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-coastal-areas.html (last visited Dec. 27, 2017).

143 *Id.*

144 *See* Zachary D. Ludens, *Stemming a Rising Tide: Why the Clean Air Act Following Massachusetts v. E.P.A. Provides a Sensible Vehicle Through Which to Regulate Greenhouse Gas Emissions*, 68 U. MIAMI L. REV. 251, 281 (2013).

145 Bryan Walsh, *The Kyoto Accords—and Hope—Are Expiring*, TIME, (Nov. 8, 2011), http://content.time.com/time/health/article/0,8599,2098887,00.html.

were set to go into force in 2005.[146] Under the Clinton administration, the U.S. signed onto the Kyoto Protocol in November of 1998, but the U.S. Senate was never willing to ratify the treaty.[147] Due to the U.S.'s lack of participation in the treaty, the Protocol never gained any significant footing outside of the European Union.[148]

Not until 2015, in the United Nations Paris Accord, did the U.S. finally consent to a global agreement to decrease its carbon dioxide emissions. Under the Paris Agreement, the U.S. and China—the world's top two carbon polluters—both agreed to mandatory cuts in emissions.[149] The U.S. agreed that, by 2025, it would emit 26 to 28 percent less carbon than it did in 2005.[150] China's pledge was to reach peak carbon emissions by 2030, if not sooner.[151]

In an effort to implement the U.S.'s commitments under the Paris Agreement, President Obama and the EPA drafted and released the Clean Power Plan in 2015.[152] The plan sought to drive down carbon emissions within the U.S., with an ultimate goal of achieving a reduction in carbon pollution by 32 percent from 2005 levels by 2030.[153] Under the Clean Power Plan, states were to be given flexible, cost-effective tools to cut carbon based on the types

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[146] *See* United Nations Framework Convention on Climate Change, Status of Ratification of the Kyoto Protocol, http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php (last visited Dec. 27, 2017).
[147] Ludens, *supra* note 144, at 281.
[148] *Id.*
[149] Mark Landler, *U.S. and China Reach Climate Accord After Months of Talks*, N.Y. TIMES, (Nov. 11, 2014), https://www.nytimes.com/2014/11/12/world/asia/china-us-xi-obama-apec.html?_r=0.
[150] *See* Press Release, The White House, U.S.-China Joint Announcement on Climate Change (Nov. 11, 2014) https://obamawhitehouse.archives.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change.
[151] *See id.*
[152] *See* Landler, *supra* note 149.
[153] *A Historic Commitment to Protecting the Environment and Addressing the Impacts of Climate Change*, THE WHITE HOUSE, https://obamawhitehouse.archives.gov/the-record/climate (last visited Feb. 25, 2017).

of energy generation they use and the capability to switch to other sources.[154]

Under President Donald Trump's new administration, the Clean Power Plan is unlikely to survive. On the Trump transition team's website, a statement declares the administration's intention to "scrap that $5 trillion dollar Obama-Clinton Climate Action Plan and the Clean Power Plan."[155] Despite this, Donald Trump, then president-elect, had a meeting with Al Gore in late 2016 and stated to the *New York Times* that "he would 'keep an open mind' about whether to pull the United States out of the Paris agreement."[156] As of March 2017, there had been no executive orders to undo the Clean Power Plan, but many officials and environmental groups believed that the Trump EPA would eventually abandon it.[157] The White House website outlines the Trump administration's "America First Energy Plan."[158] The proposal would eliminate the Climate Action Plan, embrace the shale oil and gas revolution, promote oil and gas production by opening federal lands and revive America's

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[154] Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64,661, 64,672 (U.S. Envtl. Pro. Agency Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60) [Hereinafter "Carbon Pollution Emission Guidelines"] ("state-specific, rather than source-specific, goals; a 10-year interim goal that could be met 'on average' over the 10-year period between 2020 and 2029; and a 'portfolio' option for state plans. These features were intended either to capture, in the emission guidelines, emission reduction measures already in widespread use or to maximize the range of choices that states and utilities could select in order to achieve their emission limitations at low cost while ensuring electric system reliability").

[155] Jeannine Anderson, Am. Pub. Power Ass'n, *Survival of Clean Power Plan under a Trump administration looms as a question,* MEDIUM (Jan. 10, 2017), https://medium.com/@PublicPowerOrg/survival-of-clean-power-plan-under-a-trump-administration-looms-as-a-question-8c31474ad36.

[156] *Id.*

[157] Jennifer Ludden et al., *As Obama Clean Power Plan Fades, States Craft Strategies to Move Beyond It*, NAT'L PUB. RADIO (Jan. 25, 2017, 5:16 PM), http://www.npr.org/2017/01/25/511616327/as-obama-clean-power-plan-fades-states-craft-strategies-to-move-beyond-it (Last visited Feb. 25, 2017).

[158] *An America First Energy Plan*, THE WHITE HOUSE, https://www.whitehouse.gov/america-first-energy (last visited Feb. 23, 2017).

coal industry,[159] in direct contradiction of the Clean Power Plan's purpose.

Despite the Clean Power Plan's doubtful future under the Trump Administration, many states are continuing their own efforts to reduce their carbon emissions.[160] Even some coal-rich states, that vehemently opposed the Clean Power Plan, such as North Dakota, are unsure whether the Trump administration is capable of reversing the economic realities facing the coal industry today.[161] For example, Jason Bohrer, a member of North Dakota's lignite coal trade group, recently expressed that "public demands and market forces are fueling a boom in cleaner energy" and operators must plan for the future because, even if the Trump administration opts not to tackle carbon emissions, a future president likely will.[162]

B. Global Warming's Impact on the Appeal of Nuclear Power

Since nuclear energy does not produce greenhouse gas emissions, many in recent years have advocated for nuclear energy development as a primary means of slowing climate change. Over the last two decades, energy consumption in the United States has steadily increased and is expected to continue expanding by 0.3

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[159] *Id.*

[160] *See generally Renewable Energy Sector Remains Optimistic Amid Trump Policy Outlook*, NAT'L PUB. RADIO (Dec. 22, 2016, 4:47 AM), http://www.npr.org/2016/12/22/506531165/renewable-energy-sector-remains-optimistic-amid-trump-policy-outlook (stating, "California is all in on renewables. State law requires 50 percent renewable energy by 2030. And 28 other states also have goals, most of which are likely to stick around even if the Clean Power Plan goes away").

[161] *See* Ludden, *supra* note 157.

[162] *Id.* (quoting Jason Bohrer as stating that "Donald Trump is not the cure-all for the coal industry, [t]his doesn't fix everything. It just gives us the opportunity to provide solutions." Bohrer also states that "public demand and market forces are fueling a boom in cleaner energy. Cheap wind power has grown into North Dakota's second-biggest electricity source. So even though the pressure's off to curb emissions, the state is looking to clean up coal as a way to save jobs").

percent per year until at least 2035.[163] The Union of Concerned Scientists has encouraged the world to reduce greenhouse gas emissions to below 2000 levels by at least 80 percent by 2050 to avoid potential global environmental damage.[164] Although worldwide energy consumption is predicted to increase, the task of reducing greenhouse gas emissions, while simultaneously increasing energy production, will require an increase in low-carbon emitting energy production.[165] Many proponents of renewable energy advocate for the use of solar and wind, but their opponents argue that, currently, these options cannot meet the nation's baseload power demand alone.[166] Concerns about climate change have thus contributed to a short-term renaissance of nuclear energy.[167]

In the Clean Power Plan, even the EPA contemplated nuclear power as a means of reducing greenhouse gas emissions from the power sector.[168] Three additional factors have helped with

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[163] Debra J. Carfora, *Building a Sustainable Energy Future: Offering a Solution to the Nuclear Waste Disposal Problem through Reprocessing and the Rebirth of Yucca Mountain*, 8 TEX. J. OIL GAS & ENERGY L. 143, 144 (2012–2013).

[164] LISBETH GRONLUND ET AL., UNION OF CONCERNED SCIENTISTS, NUCLEAR POWER IN A WARMING WORLD, 2 (2007), http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/nuclear-power-in-a-warming-world.pdf.

[165] Carfora, *supra* note 163, at 144 ("[N]ations must determine how to simultaneously accommodate increased energy demand and reduce GHG emissions. This task will require increase low-carbon energy production in the global energy portfolio").

[166] *See* Elaine K. Hart et al., *The Potential of Intermittent Renewables to Meet Electric Power Demand: Current Methods and Emerging Analytical Techniques*, 100 PROC. IEEE 322, 322–23 (2012).

[167] Adrian J. Bradbrook, *Sustainable Energy Law: The Past and the Future*, 30 NO. 4 J. ENERGY & NAT. RES. L. 511, 516 (2012) (stating "Climate change concerns led to a short-term renaissance of nuclear energy in the first decade of this century and helped erase memories of the 1986 Chernobyl disaster").

[168] The EPA makes a distinction between renewable energy and nuclear energy by noting that nuclear energy requires large capital-intensive investments and require substantial lead times whereas renewable energy investments are smaller and require shorter lead times. *See* Carbon Pollution Emission Guidelines, *supra* note 154, at 64,729 (explaining that under the Clean Power Plan "the EPA identified [renewable energy] generating capacity and nuclear generating capacity as potential sources of lower- or zero-CO_2 generation that could replace higher-CO_2

the resurgence of nuclear power. First, in 1989, the NRC began streamlining its permitting process and in 2002, the Department of Energy offered various incentives for potential licensees, including an offer to pay up to half the licensing costs incurred by the applicants.[169] Second, in the Energy Policy Act of 2005, Congress established several initiatives benefiting nuclear power, including nuclear tax production credits, regulatory risk insurance, and loan guarantees.[170] Finally, due to the need to reduce emissions, nuclear can be seen as an important, non-emitting power generation option.[171]

Nuclear energy, as a power source, has many advantages over carbon-intensive fossil fuels. Nuclear reactors do not produce the same greenhouse gases or other pollutants produced by coal and natural gas plants that contribute to climate change, acid rain, smog, respiratory illness and mercury deposits, among other impacts.[172] Some proponents for nuclear energy argue that it is the only carbon free energy source capable of supplying reliable baseload electricity.[173] Even over the entire nuclear life-cycle, from uranium mining to nuclear waste management, the carbon footprint of nuclear power is similar to that of renewable energy sources such as hydropower and wind.[174] Over the lifetime of a nuclear facility, it will emit 1.6

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generation from affected EGUs." The EPA also "identified the replacement of generation from fossil fuel-fired EGUs with generation from nuclear units as a potential approach for reducing CO_2 emissions from the affected source category").

[169] *See* EISEN, *supra* note 35, at 402.

[170] *Id.*

[171] *See id.*

[172] *See, e.g.*, FRED BOSSELMAN et al., ENERGY, ECONOMICS AND THE ENVIRONMENT: CASES AND MATERIALS 211 (3d ed. 2010).

[173] Zachary Robock, *Economic Solutions to Nuclear Energy's Financial Challenges*, 5 MICH. J. ENVTL, & ADMIN. L. 501, 504 (2016) (describing nuclear energy as being "the only carbon-free energy source capable of supplying reliable baseload electricity, which today is produced mainly by coal and other fossil fuels").

[174] *See Life-Cycle Emissions Analyses*, NUCLEAR ENERGY INST., https://www.nei.org/Issues-Policy/Protecting-the-Environment/Life-Cycle-Emissions-Analyses (last visited Jan. 14, 2018) (defining a life-cycle emission to include "emissions associated with the construction of the plant, mining and processing the fuel,

percent of the greenhouse gases of a similarly sized coal facility and 2.7 percent the emissions of the natural gas facility.[175] Nuclear energy currently accounts for 75 percent of the carbon free energy produced in the United States.[176] In 2010, electricity generated from nuclear power plants, as opposed to fossil-fuel powered plants, prevented the release of about 650-million metric tons of carbon dioxide into the atmosphere.[177]

In addition to creating almost no carbon dioxide emissions, nuclear power plants use a smaller portion of land per kilowatt of power generated than wind or solar farms. Nuclear power plants require a remarkably small amount of land compared to the amount of power that they can produce.[178] A single nuclear plant has roughly 1,100 megawatts in capacity, which is four to five times the size of a typical wind farm and about ten times the size of a very large solar farm.[179] Mining for uranium generally produces less waste and pollution than mining for coal, and the amount of uranium required for energy generation is fractional compared to that of coal.[180] Every year, the U.S. consumes roughly sixty-six million

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routine operation of the plant, disposal of the used fuel and other waste byproducts, and decommissioning." The report also cites the 2014 United Nations Intergovernmental Panel on Climate Change); *See also,* Thomas Bruckner, et. al., *Annex III: Technology-specific Cost and Performance Parameters*, *in* CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE (O. Edenhofer et al., eds. (2014), https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_annex-iii.pdf#page=5 (reporting that nuclear energy median lifecycle emissions are 12 gCO_2 eq/kWh. Hydropower has median lifecycle emissions of 24 gCO_2 eq/kWh. Onshore Wind facilities have a median lifecycle emissions of 11 gCO_2 eq/kWh. Offshore Wind Facilities have a median lifecycle emissions of 12 gCO_2eq/kWh. Statistics are determined by per gram of carbon dioxide emitted per kilowatt-hour of electricity produced).

[175] Cox, *supra* note 94, at 40–41; *see also* Bruckner, *supra* note 174.

[176] Randall W. Miller, *Wasting Our Options? Revisiting the Nuclear Waste Storage Problem*, 4 WASH. & LEE J. ENERGY, CLIMATE, & ENV'T 359, 363 (2013).

[177] *Id.*

[178] Cox, *supra* note 94, at 40.

[179] Daniel Gross, *The Half-Life of American's Nuclear Plants*, SLATE (Mar. 16, 2016, 10:56 AM), http://www.slate.com/articles/business/the_juice/2016/05/america_is_getting_new_nuclear_plants_in_tennessee_and_georgia_we_need_more.html.

[180] Cox, *supra* note 94, at 41.

pounds of uranium, which equates to less than five percent of the amount of annual consumption of coal.[181] Moreover, nuclear energy's reliable baseload power production makes it a more attractive option than certain renewables, like wind and solar energy. Nuclear energy works around the clock and does not require the sun to be shining or the wind to be blowing.[182]

1. Global Use of Nuclear Power to Combat Climate Change

Recognizing the advantages of nuclear power as a means of reducing carbon dioxide emissions, multiple countries across the world are seeing a nuclear renaissance in their energy sectors as well. According to the World Nuclear Association, more than twenty nuclear power plants are under construction in China and over sixty plants are under construction globally as of March 2017.[183] To lower carbon emissions and combat global warming, many countries, such as China, South Korea, UAE, and Russia, are utilizing nuclear power as a carbon-free alternative to fossil fuel. There are presently 440 nuclear plants in operation in thirty-one countries across the globe plus Taiwan.[184] China is already operating thirty-six nuclear power plants, which unquestionably displace electricity generation from coal-burning plants.[185] India has recently announced plans to supply 25 percent of its electricity from nuclear power by 2050 and, due to a lack of uranium resources, the country

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[181] *Id.*
[182] Gross, *supra* note 179.
[183] *See generally* Chris Mooney, *It's the First New U.S. Nuclear Reactor in Decades. And Climate Change Has Made This a Very Big Deal*, WASH. POST, (June 17, 2016), https://www.washingtonpost.com/news/energy-environment/wp/2016/06/17/the-u-s-is-powering-up-its-first-new-nuclear-reactor-in-decades/?utm_term=.8de0ab4df641.
[184] *Id.*
[185] *See generally Nuclear Power in China*, WORLD NUCLEAR ASSOC. (last updated Jan. 2018), http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx.

has been developing fast reactors and a nuclear fuel cycle that utilizes the nation's reserves of thorium.[186]

2. The Current State of Nuclear Power in the United States

Despite the three major nuclear accidents described above and the negative public sentiment that followed those disasters, there are likewise still dozens of nuclear power plants in operation within the U.S. As of early 2017, there were 104 nuclear reactors operating in thirty-one states, supplying approximately 20 percent of all electrical power in the country.[187] In several states, nuclear energy is the primary source of electricity.[188] The demand for electricity continues to rise and by 2040 the U.S. Department of Energy estimates an increase in U.S. demand of 22 percent.[189]

A few nuclear energy plants have recently come online, and more are currently under construction in the U.S. In Tennessee, the Watts 2 plant came online in October 19, 2016.[190] The plant will supply GHG-free power to 650,000 homes and is the first U.S. plant to fully comply with the Nuclear Regulatory Commission's new regulations stemming from the 2011 Fukushima Daiichi nuclear disaster.[191] The federal government also agreed to back a total of

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[186] *See generally Nuclear Power in India*, WORLD NUCLEAR ASSOC. (last updated Oct. 2017), http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.
[187] Miller, *supra* note 176, at 363.
[188] *Id.* at 362.
[189] *See New Nuclear Energy Facilities,* NUCLEAR ENERGY INST., https://nei.org/Issues-Policy/New-Nuclear-Energy-Facilities (last visited Feb. 26, 2017) ("[t]he U.S. Department of Energy projects that U.S. electricity demand will rise 22 percent by 2040.").
[190] *Watts Bar Unit 2 Timeline,* TENNESSEE VALLEY AUTH., *available at* https://www.tva.com/Newsroom/Watts-Bar-2-Project/Timeline (last visited February 26, 2017) ("[t]he nation's first new nuclear generation in 20 years officially entered commercial operation on October 19, 2016.").
[191] Mooney, *supra* note 183; *See also* Robert M. Taylor, *Japan Lessons Learned NRC Regulatory Activities Following Fukushima Dai-ichi Accident*, UNITED STATES NUCLEAR REGULATORY COMMISSION, *available at* http://nas-sites.org/fukushima/files/2013/01/NRC_Taylor.pdf (last visited Mar. 7, 2017)

$8.3 billion in loans to finance construction of Vogtle Units 3 and 4 in Georgia.[192] The Vogtle Units are the first U.S. implementations of the Westinghouse reactor design.[193] The Westinghouse design improves upon prior designs by incorporating passive safety features that do not require active controls or operator intervention, but rely instead on gravity or natural convection to mitigate the impact of abnormal events.[194] The Gen III+ reactors, which are used in the Vogtle Units, are also designed to increase fuel burnup, thus reduce fuel consumption and waste production.[195] South Carolina likewise has two nuclear energy plants under construction, V.C. Summer Units 2 and 3.[196] Once constructed and fully operational, these five nuclear power plants will add approximately 6,000 megawatts of new capacity for the nation.[197] New subsidies for existing nuclear energy facilities have also increased in recent years, including the bailout for aging nuclear plants in upstate New York.[198]

(describing the new regulations implemented post Fukushima, including but not limited to: regulatory actions, mitigation strategies, technological changes, and emergency preparedness strategies).

[192] *See Financing Vogtle: A Major Achievement for the Loan Programs Office*, U.S. DEPT. OF ENERGY (Jun. 24, 2015) https://energy.gov/lpo/articles/financing-vogtle-major-achievement-loan-programs-office (describing federal government financing of new nuclear reactors to be built in Georgia).

[193] *See Plant Vogtle 3 & 4*, GEORGIA POWER, https://www.georgiapower.com/about-energy/energy-sources/nuclear/overview.cshtml (last visited Mar. 7, 2017) (explaining the new technology being used in the Vogtle reactors).

[194] *See* STEPHEN M. GOLDBERG & ROBERT ROSNER, NUCLEAR REACTORS: GENERATION TO GENERATION 8 (2011).

[195] *See AP1000 Nuclear Power Plant—Passive Safety Systems*, WESTINGHOUSE, http://www.westinghousenuclear.com/New-Plants/AP1000-PWR/Safety/Passive-Safety-Systems (last visited Mar. 7, 2017) (describing passive safety systems in the AP1000 reactor design).

[196] *See* Roddie Burris, *VC Summer Nuclear Plant, Under Construction, Opened for Media Tour*, STATE, (Sept. 21, 2016, 11:13 PM), http://www.thestate.com/news/business/article103353107.html (describing the construction of the VC Summer nuclear plant).

[197] Gross, *supra* note at 179.

[198] Patrick McGeehan, *New York State Aiding Nuclear Plants with Millions in Subsidies*, N.Y. TIMES (Aug. 1, 2016), https://www.nytimes.com/2016/08/02/nyregion/new-york-state-aiding-nuclear-plants-with-millions-in-subsidies.html

3. The Unique Costs of Nuclear Power

Despite nuclear energy's advantages as a means of combatting global warming by generating stable, carbon-free baseload power, nuclear power has some unique disadvantages that distinguish it from other energy strategies such as solar and wind. This section discusses several often-ignored negative externalities of nuclear power and argues that these additional costs prevent nuclear power from being on par with renewables like wind and solar as a response to global warming.

As research recently conducted by the International Energy Agency concluded, nuclear energy should not be considered an integral part of the planet's long-term sustainable energy strategy.[199] The numerous unique costs of nuclear power, including those associated with plant construction, safety, nuclear waste storage and disposal, limited supplies of high grade uranium, proliferation, and terrorism risk, seemingly outweigh the benefits.

One social cost of nuclear power is the significant environmental risk associated with uranium mining and milling. There are three types of Uranium mines: open pit, underground, and in-situ leach.[200] As of 2015, there were eight uranium mines operating in the United States, of those, seven were of the in-situ leaching type and one is an underground mine.[201] The mining process for both open pit and underground mines involves extraction and milling of uranium ore from the ground.[202] The milling process generally produces a radioactive sludge called tailings, which contains

(observing that customers in New York State will pay $500 million a year in subsidies aimed at keeping some upstate nuclear power operating).

[199] *See* Adrian J. Bradbrook, *Sustainable Energy Law: The Past and the Future*, 30 J. ENERGY & NAT. RESOURCES L. 511, 517 (2012) (describing that nuclear power is not a feasible, sustainable energy solution for the next thirty years).

[200] *See* Chris Losi, *Radioactive Optimism: Japan's Nuclear Power Plants and New Mexico's Crownpoint Uranium Mine*, ARIZ. J. ENVTL. L. & POL'Y (2011) https://www.ajelp.com/AJELP_Blog_Feb11.cfm.

[201] *See* U.S. ENERGY INFO. ADMIN., 2016 DOMESTIC URANIUM PRODUCTION REPORT 5 (2017).

[202] *See* Losi, *supra* note 200, at 2.

radium-226.[203] This radioactive material can be absorbed by plants and passed up the food chain to humans.[204] The most commonly used uranium mining technique, in-situ leach mining (ISL), involves the injection of chemical fluid into wells drilled into uranium ore.[205] The chemical fluids "leach" uranium out of the deposits, which then comes to the surface through recovery wells.[206] While the ISL process is supposed to be more environmentally benign than traditional mining and milling, the process still contaminates the groundwater aquifer in and around the region of uranium extraction.[207]

The initial construction of nuclear power plants is also an immense and potentially dangerous undertaking. Nuclear power plant construction requires the assembly of thousands of moving parts. To generate power, the plant requires a long list of components such as generators, turbines, cooling towers, electrical and cooling systems, and safety systems, any of which could fail.[208] Currently, "nuclear reactors have a lifespan of thirty to forty years

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[203] *See id.* ("Radium-226 is about one million times more active than uranium, chemically similar to calcium, and when ingested [, a small fraction] is deposited in bone... Radium-226 decays into radon gas which causes lung cancer if inhaled in sufficient quantities." Radium-226 has a half-life of approximately 1600 years).

[204] *Id.*

[205] Edward W. Harris, *State Groundwater and Reclamation Permitting Regimes and their Application to Uranium Exploration and Mining*, *in* APRIL 2006 ROCKY MTN. MIN. L. INST. 5-1 (2006) (noting that in 2004, there were twice as many in situ facilities as conventional. During the in-situ process, fluid is injected underground through wells into the uranium ore body).

[206] Rebecca Tsosie, *Indigenous Peoples and the Ethics of Remediation: Redressing the Legacy of Radioactive Contamination for Native Peoples and Native Lands*, 13 SANTA CLARA J. INT'L LAW 203, 255 (2015).

[207] *See* U.S. NUCLEAR REGULATORY COMM'N, CONSIDERATION OF GEOCHEMICAL ISSUES IN GROUNDWATER RESTORATION AT URANIUM IN-SITU LEACH MINING FACILITIES 17 (2007) (explaining that because many aquifers have low permeability, it is very difficult to remove all of the contaminants from the subsurface, even after long periods of pumping and treatment).

[208] *See* Benjamin K. Sovacool & Christopher Cooper, *Nuclear Nonsense: Why Nuclear Power Is No Answer to Climate Change and the World's Post-Kyoto Energy Challenges*, 33 WM. & MARY ENVTL. L. & POL'Y REV. 1 (2008) (explaining the thousands of parts and multiple systems that need to work in conjunction to generate nuclear power and how all of which have the potential to fail).

but are able to produce electricity at full capacity for no more than twenty-four years."[209]

Even at the end of a nuclear power plant's life cycle, it continues to impose costs on society. The final stage in the nuclear fuel cycle includes the decommissioning and dismantling of the reactor and the reclamation of the uranium mine site.[210] Once a nuclear plant has completed its power generating phase, its spent fuel is processed, stored and cooled, at the reactor site for a minimum of ten years. This spent fuel is then transferred to concrete casks to be put into permanent storage,[211] where it will continue to be radioactive and hazardous for tens of thousands of years.

III. NUCLEAR POWER IS NOT AS ENVIRONMENTALLY FRIENDLY AS SOLAR AND WIND ENERGY

As U.S. energy policies focus more on curbing greenhouse gas emissions and less on the other costs and benefits associated with various energy strategies, policymakers are increasingly under-accounting for the unique risks and costs associated with nuclear power. Nuclear energy does not warrant policy treatment that is as favorable as that given to wind and solar energy, which involve far fewer environmental risks and long-term societal costs. Therefore,

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[209] *See id.* at 9.

[210] *See* DAVID FLEMMING, THE LEAN GUIDE TO NUCLEAR ENERGY A LIFE-CYCLE IN TROUBLE 7 (2007) (explaining that "Nuclear reactors at present have a lifetime of about 30–40 years, but produce electricity at full power for no more than 24 years; the new European Pressurized Water Reactors (EPR), it is claimed, will last longer. During their lifetimes, reactors have to be maintained and (at least once) thoroughly refurbished; eventually, corrosion and intense radioactivity make them impossible to repair. Eventually, they must be dismantled, but experience of this is limited. As a first step, the fuel elements must be put into storage; the cooling system must be cleaned to reduce radioactive corrosion residuals and unidentified deposits (CRUD). These operations, together, produce about 1,000 m3 of high-level waste. After a cooling-off period which may be as much as 50–100 years, the reactor has to be dismantled and cut into small pieces to be packed in containers for final disposal. The total energy required for decommissioning has been estimated at approximately 50 percent more than the energy needed in the original construction").

[211] *See* Sovacool & Cooper, *supra* note 208, at 9.

policymakers must be careful not to adopt overly favorable perceptions of nuclear energy or ignore its true costs when structuring energy policies.

Some environmentalists are beginning to support the idea of nuclear power serving as a bridge to provide carbon-free energy in the short term while renewable technologies such as solar and wind energy continue to develop and advance.[212] However, many other environmentalists are vehemently opposed to the use of nuclear power all together.[213] In June 2005, 313 environmental groups issued a statement in which they concluded that the health, safety, and economic risks associated with nuclear power were "too high to consider it as a potential solution to climate change."[214]

Some other policymakers have argued that nuclear energy should be treated on par with renewable energy because of its similarity to wind and solar energy in that none of these energy strategies generate carbon dioxide emissions. Unfortunately, those advocating for similar treatment arguably fail to fully recognize many of the unique costs associated with nuclear power. To more clearly understand why nuclear energy is not well suited to be a primary means of addressing climate change, it is important to first dispel the myths surrounding comparisons of nuclear energy to renewable energy. The following subsections will discuss the negative externalities associated with solar and wind versus those

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212 Mariah Zebrowski, *Nuclear Power as Carbon-Free Energy? The Global Nuclear Energy Partnership* 20 COLO. J. INT'L ENVTL. L. & POL'Y 391, 400 (2009) (illustrating the drawbacks concerned with renewable energies like wind, solar and hydropower. The author points out "[a]lthough new renewable energy technologies are promising, most are more than ten years away from large-scale production").

213 *See infra* note 214 and accompanying text.

214 *See* Len Ackland, *Environmentalists Debate Nuclear Power Luncheon Presentation*, *in* APRIL 2006 ROCKY MTN. MIN. L. INST. 4-1 (2006) ("we believe that the financial and safety risks associated with nuclear power are so grave that nuclear power should not be a part of any solution to address global warming. There is no need to jeopardize our health, safety, and economy with increased nuclear power when we have cleaner, cheaper solutions to reduce global warming pollution").

associated with nuclear power, and highlight the disparity in size between each set of costs.

A. Societal Costs Associated with Solar Energy

Although solar power generates electricity in ways that impose far fewer social costs on humankind and the environment than those associated with nuclear energy, it is not a costless form of energy generation.

Solar energy facilities generate clean and sustainable electric power free of greenhouse gases and produce minimal pollution.[215] Solar power is an abundant and inexhaustible resource that can be harnessed and converted into electricity anywhere that there is access to sunlight.[216] This energy can be harvested in a wide range of ways, from a small array of photovoltaic solar panels atop the roof of a residential home, to a utility-scale solar energy plant.[217] Utility-scale operations can convert solar power into electricity through two different types of technology: photovoltaic (PV) solar cells or concentrating solar thermal plants (CSP).[218] Although residential-scale solar PVs arrays can impose some limited costs on neighbors, it is the utility-scale plants that are often cited in discussions about the environmental and other external costs of solar energy.[219]

One notable disadvantage of solar energy is the amount of land needed to support utility-scale solar generating facilities. The land footprints of utility-scale PV systems tend to vary between 3.5 to 10 acres per megawatt, while CSP facilities range between 4 to

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[215] *Environmental Impacts of Solar Power*, UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-solar-power.html#bf-toc-3 (last revised Mar. 5, 2013).

[216] *See* JOHN NOLON & PATRICIA SALKIN, CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT LAW IN A NUTSHELL 328 (West 2011).

[217] *Id.*

[218] *See Environmental Impacts of Solar Power*, *supra* note 215.

[219] *See* TROY A. RULE, SOLAR, WIND AND DEVELOPMENT CONFLICTS IN RENEWABLE ENERGY DEVELOPMENT 89 (2014).

16.5 acres per megawatt.[220] The Ivanpah Solar Electric Generating System, sited in the Mojave Desert, encompasses an area of 3,500 acres.[221] Utility-scale development also threatens to displace the animals and plant-life whose habitats would ultimately be destroyed. The Ivanpah CSP project was sternly opposed by environmentalists over the loss of habitat of the desert tortoise, an animal protected under the U.S. threatened species list.[222] BrightSource, the developer of Ivanpah, ultimately spent more than $56 million in an effort to relocate the tortoises displaced by the project.[223] However, land impacts from utility-scale solar systems could be minimized by siting them at lower-quality locations such as brownfields, abandoned mining land, or existing transportation and transmission corridors.[224]

The materials used in manufacturing solar PV cells also impose environmental and social costs. Solar PV cells contain several types of raw materials that must be mined from sites across the world. This extraction of minerals has the potential to harm animal habitats.[225] The solar PV cells' manufacturing process includes numerous hazardous materials.[226] Some of the chemicals used to clean and purify the semiconductor surface include hydrochloric acid, sulfuric acid, nitric acid, and acetone.[227] Additionally,

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220 *Environmental Impacts of Solar Power*, *supra* note 215.

221 *Ivanpah Solar Electric Generating System*, NAT'L RENEWABLE ENERGY LAB. (Nov. 20, 2014), https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=62.

222 *See* RULE, *supra* note 219, at 89.

223 *Id.* at 90.

224 *See Renewable Energy Projects at Mine Sites*, U.S. ENVIRONMENTAL PROTECTION AGENCY, https://semspub.epa.gov/work/HQ/100000041.pdf (last updated 2015) (highlighting successful renewable energy projects that have been completed at lower quality conditions).

225 *See* RULE, *supra* note 219, at 77.

226 *See Environmental Impacts of Solar Power*, *supra* note 215 (toxic materials include "gallium arsenide, copper-indium-gallium-diselenide, and cadmium-telluride").

227 *See* Benjamin K. Sovacool & Christopher Cooper, *Congress Got It Wrong: The Case for a National Renewable Portfolio Standard and Implication for Policy*, 3 ENVTL & ENERGY L. & POL'Y J.85, 87 (2008).

workers face risks associated with inhaling silicon dust.[228] The use of these chemicals requires PV manufacturers to adhere to strict U.S. laws to ensure that workers are not harmed or exposed to the chemicals used and that manufacturing waste products are properly disposed of.[229] The PV cells themselves are composed of a number of toxic materials and, if not handled properly, these materials could pose serious environmental or public health risks.[230]

Like fossil fuel and nuclear energy plants, CSP plants also require water to generate electricity and such water can be precious and expensive in some arid regions.[231] CSP plants using water generate electricity through one of two ways: wet-recirculating technology or once-through cooling technology.[232] CSP plants that use wet-recirculating technology with cooling towers use between 600 and 650 gallons of water per mega-watt hour of electricity produced.[233] CSP plants with once-through cooling technology have higher levels of water withdrawal, but the amount of total water consumption is considerably lower because the water is not lost as steam.[234] CSP plants can use dry-cooling technology to reduce their water consumption levels by 90 percent, which creates a viable option for plants situated in places with limited amounts of water.[235]

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[228] *See Environmental Impacts of Solar Power*, *supra* note 215.
[229] *Id.*
[230] *See* Dustin Mulvaney, *Solar Energy Isn't Always as Green as You Think*, IEEE SPECTRUM (Nov. 13, 2014, 4:00 PM), https://spectrum.ieee.org/green-tech/solar/solar-energy-isnt-always-as-green-as-you-think (stating that the chemicals contained in PV cells can cause "inheritable mutations").
[231] *See How It Works: Water for Power Plant Cooling*, UNION OF CONCERNED SCIENTISTS, *available at* http://www.ucsusa.org/clean-energy/energy-and-water-use/water-energy-electricity-cooling-power-plant#.WLiWjhCZS34 (last visited Mar. 2, 2017).
[232] *See id.* (the report also notes dry-cooling systems as an additional type of cooling used at thermoelectric plants. Dry-cooling systems use air instead of water to cool the steam which can decrease water consumption by 90 percent).
[233] *See* Paul Gosselink, et al., *Resource Acquisition*, *in* Tex. Prac., Environmental Law, § 27:17 (Jeff Civins et al., eds. 2d ed. 2016).
[234] *Id.*
[235] *See* R.R. Hernandez et al., *Environmental Impacts of Utility-Scale Solar Energy*, 29 RENEWABLE & SUSTAINABLE ENERGY REV. 766, 770 (2014).

In summary, although solar energy generation does involve some costs that are not always borne by those who generate the power, those externalities are typically to a lesser degree than those associated with fossil fuel-fired or nuclear energy. Many of the negative externalities of solar energy development, such as land use, displacement of wildlife, and water consumption, also exist to some degree in connection with fossil fuel and nuclear energy. However, the reverse is not true: solar energy development does not generate many of the costs that plague nuclear energy.

B. Social Costs Associated with Wind Energy

Responsible wind energy development also imposes comparatively fewer costs on the environment and humankind than nuclear power. One often-cited, adverse environmental impact of wind energy production is the potential harms that wind turbines can inflict on bird and bat species. According to a 2013 study by the *Wildlife Society Bulletin*, over 573,000 bird deaths in the U.S. each year are caused by wind farms.[236] Of these deaths, roughly 83,000 involve small and medium-sized birds of prey.[237] Bird deaths usually occur when birds are struck by the wind turbine blades or from destabilization caused by vortices.[238]

Bird deaths are not the only winged species affected by the wind turbines. Wind turbines are linked to roughly 888,000 bat deaths each year.[239] Unlike birds, bats are effective at navigating around wind turbines, but the rapid decrease in air pressure behind turbine blades can cause bats to suffer from pulmonary barotrauma—fatal lung damage that causes the bats' lungs to rupture.[240]

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[236] *See* K. Shawn Smallwood, *Comparing Bird and Bat Fatality-Rate Estimates Among North American Wind-Energy Projects*, 37 WILDLIFE SOC'Y BULL. 19, 26 (2013).
[237] *Id.*
[238] *See* RULE, *supra* note 219, at 80–81.
[239] *See* Cris D. Hein & Michael R. Schirmacher, *Impact of Wind Energy on Bats: A Summary of Our Current Knowledge*, 10 HUM.-WILDLIFE INTERACTIONS 19, 21 (2016).
[240] *See* RULE, *supra* note 219, at 86.

Many wind energy developments also draw opposition due to local concerns about noise, aesthetic impacts, or other impacts, consistent with the Not-In-My-Back-Yard (NIMBY) mentality that often plagues industrial-scale development projects.[241] One of the most frequent objections to new wind energy developments is that the wind turbines will tarnish the aesthetic beauty of surrounding landscapes due to their enormous size.[242] Famously unsuccessful projects, such as the "Cape Wind" project, have illustrated how aesthetics-based opposition can delay or even thwart the construction of an off-shore wind project.[243] Cape Wind was a proposed offshore wind energy project off the coast of Massachusetts.[244] The project was to include approximately 130 wind turbines spread over 25 square miles which would be sited over five miles away from the shore.[245] Even though the turbines would appear no taller than a half-inch from the shoreline, many residents with beachfront properties were adamantly opposed, fearing that the turbines would impact their views and property values.[246] In addition to aesthetics-based

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[241] *See* Nolon & Salkin, *supra* note 216, at 321.

[242] *See* Rule, *supra* note 219, at 22 (typically wind turbines stand over 400 feet in height).

[243] *See* Kenneth Kimmell & Dawn Stolfi Stalenhoef, *The Cape Wind Offshore Wind Energy Project: A Case Study of the Difficult Transition to Renewable Energy*, 5 GOLDEN GATE U. ENVTL. L.J. 197, 201 (2011) (The authors name Edward Kennedy and Bill Koch as being property owners who opposed the project. "Also in opposition are many well-heeled property owners, such as Bill Koch, who . . . opposes the Cape Wind project on aesthetic grounds.").

[244] Cape Wind is a proposed project located in the "Horseshoe Shoals" in Nantucket Sound, a body of water near Cape Cod, Martha's Vineyard and Nantucket. *Cape Wind Lease Area*, BUREAU OF OCEAN ENERGY MGMT. (2012), https://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/Studies/Lease%20Area.pdf.

[245] *See* U.S. DEPT. OF THE INTERIOR MINERALS MANAGEMENT SERVICE, CAPE WIND ENERGY PROJECT FINAL ENVIRONMENTAL IMPACT STATEMENT, E-2, 2-6, 5-245 (2009), https://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/Studies/Cape%20Wind%20Energy%20Project%20FEIS.pdf.

[246] *See* Kimmell, *supra* note 243, at 201–02 (noting Bill Koch and others have funded a nonprofit group which has spent over $15 million over the past ten years which has brought multiple lawsuits in an effort to stop the project).

opposition, landowners often complain about the shadow flicker effect caused by the rotating turbines.[247]

Like solar energy, wind energy production generates some adverse environmental and social impacts. Generally, such costs remain significantly less severe than those associated with nuclear energy. Aesthetic impacts and mild turbine noise, while a nuisance for some, are seemingly more palatable negatives than those related to nuclear energy and can often be mitigated through proper planning and siting.

IV. WHY ARE POLICYMAKERS INCREASINGLY TREATING NUCLEAR POWER AND RENEWABLES AS EQUIVALENT?

In an effort to move away from carbon-based energy and combat global warming, policymakers are increasingly placing nuclear power in the same category as clean, renewable, and sustainable energy strategies such as wind and solar energy, despite nuclear power's additional costs. The main argument for categorizing nuclear power as "clean," alongside wind and solar energy, is that it does not emit carbon dioxide. Unfortunately, this characterization of nuclear power often ignores some costs associated with nuclear energy generation that can be inconspicuous at first glance, but are far too significant to be ignored.

Some policymakers seem increasingly eager to overlook the true costs of nuclear power in their zeal to address concerns over global warming.[248] Their failure to fully account for the true costs of

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[247] *See* AMERICAN WIND ENERGY ASSOCIATION, WIND ENERGY SITING HANDBOOK § 5.4.1, 5-33 (2008), http://awea.files.cms-plus.com/Chapter_5_ Impact_Analysis_and_Mitigation.pdf (The shadow-flicker effect is described as an effect "caused by the shadows cast by moving wind turbine blades when the sun is visible. This can result in alternating changes in light intensity perceived by viewers," that typically occur during times when the sun is at a low angle, specifically "just after sunrise and just before sunset, and in relatively higher latitudes." The full version of the Wind Energy Siting Handbook can be found at http://www.awea.org/Issues/Content.aspx?ItemNumber=5726).

[248] *See* Daniel A. Farber, *Uncertainty*, 99 GEO. L.J. 901, 909 (2011) ("Risk analysis requires that risks be quantified. Not all risks can be readily quantified, and a focus on conventional risk analysis can lead to disregard of non-quantifiable

nuclear energy production contributes to the undervaluing of the totality of risks associated with nuclear power expansion as a global warming solution. There is an understandable sense of urgency because of the dire consequences associated with global warming, if sustainable and clean energy sources are not developed.[249] Even with the desperate need to move away from carbon energy, it is concerning that agencies, such as the NRC, that are tasked with nuclear power risk assessment would fail to acknowledge risks simply because the risk is not quantifiable through conventional risk analysis.[250]

A. Bounded Rationality and Nuclear Energy Policy

Bounded rationality theory offers one set of possible explanations for why some policymakers and members of the general public under-consider the unique costs of nuclear power. Bounded rationality is an economic decision-making theory developed by economist, Herbert Simon.[251] Simon advanced the theory that "the human mind necessarily restricts itself and is essentially bounded by cognitive limits."[252] Due to this "bounded rationality," individuals do not seek to maximize the benefits of a given course of action because humans do not possess the capacity to access all the information, and even if possible, their minds would be unable to process all of it.[253] Instead, people seek a solution that is satisfactory or "good enough," but not necessarily the most optimal.[254]

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risks. This can bias decision making and mislead the public about the possible consequences. A policy of ignoring all non-quantifiable harms is literally a recipe for disaster—consider the chance of a hijacked airplane being crashed into a building pre-2001 or the chance of a market meltdown pre-2009. Neither risk was quantifiable, and ignoring the risks led to catastrophic outcomes.").

[249] *See id.*

[250] *See id.*

[251] *See* Tim Hindle, *Guru: Herbert Simon,* ECONOMIST (Mar. 20, 2009), http://www.economist.com/node/13350892 (describing bounded rationality in basic terms).

[252] *Id.*

[253] *Id.*

[254] *Id.*

According to bounded rationality theory, full rationality requires unlimited cognitive capabilities.[255] Human cognitive capabilities are limited, and for this reason, human decision making behavior cannot accommodate full rationality.[256] A decision maker may be cognizant that a choice is the only rational one and still not take it.[257] Applying bounded rationality theory helps to at least partly explain the recent renaissance for nuclear power.

1. Path Dependency and Efforts to Prop Up Aging Nuclear Plants

Path dependency and inertia problems are one type of bounded rationality. This results when, even with the availability of a new path that would provide a better result, decision-making continues on an existing path.[258] Scholars have argued that path dependency may perpetuate an inferior standard even though new technology is objectively superior.[259] This effect is arguably present when policymakers opt to focus on nuclear power as a "zero-emissions" power source and "satisfactory" solution to global warming even though incentivizing nuclear energy investment is not the "optimal" policy solution. In comparison to wind and solar, nuclear power is familiar, well-established, and represent the path of

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[255] *See* Reinhard Selten, *What is Bounded Rationality?*, DAHLEM CONFERENCE 1999 3 (1999), http://www.wiwi.uni-bonn.de/sfb303/papers/1999/b/bonnsfb454.pdf ("Full rationality requires unlimited cognitive capabilities. Fully rational man is a mythical hero who knows the solutions of all mathematical problems and can immediately perform all computations, regardless of how difficult they are. Human beings are very different. Their cognitive capabilities are quite limited. For this reason alone, the decision behavior of human beings cannot conform to the ideal of full rationality").

[256] *Id.*

[257] *See* Hindle, *supra* note 251.

[258] *See* Frank A. Felder, *Climate Change Mitigation and the Global Energy System*, 25 VILL. ENVTL. L.J. 83, 89 (2014) (describing the effect path dependency and inertia exert on decision-making).

[259] *See* Alan Devlin, *Analyzing Monopoly Power Ex Ante*, 5 N.Y.U. J.L. & BUS. 153, 183 (2009) (citing Joseph Farrell & Gareth Saloner, *Installed Base and Compatibility: Innovation, Product Preannouncements and Predation*, 76 AM. ECON. REV. 940 (1986)).

least resistance. In addition to generating zero carbon emissions, nuclear power is readily compatible with the existing grid and requires minimal infrastructure investment to work within the nation's current electricity transmission systems. In the case of existing power plants, inertia and path dependency effects can allow the additional infrastructure costs and uncertainty associated with moving away from nuclear power to seem more daunting than they really are.[260] Thus, the option to continue along the existing path of nuclear power to combat global warming may garner greater support than a new option involving wind or solar energy, even if such new paths are optimal as public policy.[261]

One specific example of the possible influence of path dependency and inertia in the nuclear energy renaissance is the recent influx of public investment into New York's aging nuclear energy plants. Policymakers in New York elected to continue to infuse billions of dollars into aging nuclear plants to keep them running and competitive with cheap natural gas and renewables, even though such a move is questionable from a long-term perspective.[262] This massive investment was particularly troubling as to the Indian Point reactors, which are more than forty years old and have shown signs of significant wear and tear in parts of the reactor core.[263]

2. Excessive Optimism Regarding the Safety of Nuclear Energy

Excessive optimism is another type of bounded rationality that may be helping to fuel the nuclear energy renaissance. The

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[260] Elizabeth Kirk et al., *Path Dependency and the Implementation of Environmental Regulation*, 25 ENV'T & PLAN. C: GOV'T & POL'Y 250, 250–68 (2007) (describing how path dependency and inertia contribute to bounded rationality).
[261] *Id.*
[262] Grossman, *supra note* 1.
[263] Jeff Tollefson, *Nuclear Power Plants Prepare for Old Age*, NATURE (Aug. 30, 2016), NATURE, http://www.nature.com/news/nuclear-power-plants-prepare-for-old-age-1.20499.

famous economist, Adam Smith, was convinced that most people display a trait which modern psychologists refer to as "unrealistic optimism": In Smith's words, "[t]he chance of gain is by every man more or less overvalued and the chance of loss by most men undervalued and by scarce any man valued more than it is worth."[264] Some policymakers may exhibit excessive optimism in their discounting of the low-probability catastrophic risks associated with nuclear power. As time passes after a major nuclear incident, many individuals' confidence increases that a similar event will not occur again. To continue to operate aging nuclear plants that have verified signs of wear in the reactor core arguably displays the type of excessive optimism that contributed to catastrophic disasters such as the BP Deepwater Horizon oil spill and the Fukushima nuclear disaster.

Excessive optimism can cause individuals to look primarily to the past for guidance regarding decisions about the future and thereby undervalue risks if those risks have not historically resulted in major harms.[265] For example, some policymakers deem nuclear power incredibly safe, because there has been only one accident of note in the United States, Three Mile Island, in which the reactor meltdown was contained and there were no immediate deaths or injuries from the accident. Unfortunately, this matter of thinking can be deceiving and extremely hazardous in some contexts, as the disasters at Deepwater Horizon and Fukushima showed.

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[264] *See* Marta P. Coelho, *Unrealistic optimism: still a neglected trait*, 25 J. BUS. & PSYCHOL., 397, 397 (2010) (describing Adam Smith's quote on excessive optimism).

[265] *See* Henry Kaufman, *Excessive Optimism and Other Economic Biases*, WALL ST. J. (Aug 2 2011, 7:19 PM), http://www.wsj.com/articles/SB10001424053111903554904576458362377773274 ("Academicians and private-sector economists alike are heavily influenced by behavioral biases. On the whole, these biases discourage analysts and market participants from accepting the likelihood of panics, crises and other financial mishaps. Consider, for example, the all-too-human propensity to minimize risk and avoid isolation. It is comforting to run with the crowd. Doing so minimizes the likelihood of getting singled out for being wrong. When it comes to looking ahead, we inescapably look to the past for guidance. Yet it is important to keep in mind that history never exactly repeats itself, but rather (as Mark Twain reportedly said) it rhymes. The real challenge is to identify what is different in the current situation from the past").

On April 20, 2010, an explosion on the British Petroleum (BP) Deepwater Horizon offshore oil rig in the Gulf of Mexico killed eleven workers. The rig's well flow was not contained for 87 days, making the explosion the worst oil spill in the nation's history.[266] An investigation by an independent, nonpartisan commission issued a report concluding that the well blowout could be traced to a series of identifiable mistakes that revealed systemic failures in risk management.[267] BP's decision-making process was heavily influenced by financial considerations and under-considered the value of protecting against catastrophe.[268] Excessive optimism appears to have contributed to the overconfidence of BP's managers about the company's ability to control "gas kicks," and these managers made the grave mistake of overly relying on past success as an indicator of future success.[269]

Excessive optimism appears to have likely contributed to the 2011 Fukushima nuclear disaster. The meltdown at Japan's Fukushima Daiichi nuclear energy plant occurred on March 11, 2011, following a tsunami that made landfall and flooded the facility.[270] In this instance, government officials and the electric utility that operated the plant were arguably excessively optimistic in their belief that it was not plausible that a tsunami could flood the plant's backup and safety systems and cause a meltdown.[271]

In the aftermath of the Fukushima disaster, executives of Tepco—the utility that operated the Fukushima plant—suggested

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[266] EISEN, *supra* note 35, at 290.

[267] *See* Jerome Dauvergne, A STUDY OF BEHAVIORAL DECISION MAKING: BP AND THE DEEPWATER HORIZON DISASTER, 9 (Jul. 16, 2012), http://www.slideshare.net/JeromeDauvergne/deepwater-horizon-oil-spill-29814608 (describing in detail the behavioral dynamics and corporate culture that lead to the Deepwater Horizon disaster).

[268] *Id.*

[269] *Id.*

[270] *See* Danielle Demitriou, *Japan Earthquake, Tsunami and Fukushima Nuclear Disaster: 2011 Review*, TELEGRAPH (Dec. 19, 2011, 7:30AM) *available at* HTTP://WWW.TELEGRAPH.CO.UK/NEWS/WORLDNEWS/ASIA/JAPAN/8953574/JAPAN-EARTHQUAKE-TSUNAMI-AND-FUKUSHIMA-NUCLEAR-DISASTER-2011-REVIEW.HTML (explaining what caused the meltdown at Fukushima).

[271] EISEN, *supra* note 35, at 410.

that the rarity of such a tsunami was beyond the scope of their contingency planning.[272] In contrast, the Fukushima Nuclear Accident Independent Investigation Commission accused the government, Tepco, and nuclear regulators of failing to carry out basic safety measures, despite being aware that earthquakes and tsunamis could potentially cause the very scenario that occurred.[273]

The excessive optimism that contributed to the Deepwater Horizon and Fukushima disasters are arguably present, to at least some degree, with respect to nuclear power in the U.S. There are several ways in which policymakers indulge in excessive optimism when it comes to nuclear power. As mentioned previously, policymakers overestimate the safety of nuclear power generation, based on the limited occurrence of accidents in the past. In the United States, there has only been the Three Mile Island accident and that meltdown was contained with no immediate casualties.[274] Their past "success" in containing the meltdown can lead policymakers to become overconfident regarding their ability to prevent and contain meltdowns in the future.

In the U.S., terrorism is one particular risk for which excessive optimism may exist with regard to nuclear power. Among other things, it is conceivable that terrorists could attack a U.S. nuclear plant and thereby cause the release of radioactive material into the environment, either through causing a core meltdown or compromising spent fuel pools.[275] Like the Indian Point facility, only twenty-two miles from New York City, several nuclear power facilities throughout the nation are situated near heavily populated urban

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[272] *See* Hiroko Tabuchi, *Inquiry Declares Fukushima Crisis a Man-Made Disaster*, N.Y. TIMES (July 5, 2012), https://nyti.ms/M74j3w (describing Tepco's attempts to frame the tsunami as such a rarity that its occurrence was beyond the scope of any contingency planning).

[273] *See id.*

[274] *See* Geist, *supra* note 12.

[275] *See* PHYSICIANS FOR SOC. RESPONSIBILITY, NUCLEAR POWER AND THE TERRORIST THREAT, http://action.psr.org/site/DocServer/nuclear_power_and_the_terrorist_threat.pdf?docID=401 (observing the vulnerability of nuclear plants to terrorist attack and the likelihood radioactive material being released into the environment if an attack were to be carried out).

centers.[276] This proximity to large urban centers creates additional security risks in the event of a significant terrorist attack on a nuclear energy facility, because of the potential difficulty of evacuating millions of people in a minimal window of time.

A report commissioned by the Federal Emergency Management Agency (FEMA), noted that "nuclear facilities are prime candidates for nuclear targeting or conventional bombing."[277] U.S. nuclear plants are most vulnerable to attack at their reactors and their spent fuel rod cooling pools.[278] To the extent that some nuclear plants are ill-equipped to handle severe fires, there are also risks that a terrorism-caused fire could ultimately lead to the simultaneous failure of several complex safety systems and trigger a meltdown.[279]

In the years following the tragic events of September 11, 2001, many federal and state agencies have received threats against U.S. nuclear facilities, which begs the question of why does the NRC refuse to include the possibility of terrorist attacks in its environmental impact studies just because they cannot quantify the possibility of an attack?[280] It is unjustifiable to ignore the risk merely because it is difficult to quantify. The NRC has been accused in the past of ignoring uncertainties to reach a desired policy result when assessing the risk of a proposed nuclear power facility.[281] Under the National Environmental Policy Act (NEPA), the NRC is obligated to examine the environmental consequences of a terrorist attack if the risk is not insignificant and is not permitted to ignore a risk by labeling it "unquantifiable".[282] Policymakers' focus on

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[276] *See id.*
[277] *See id.*
[278] *Id.*
[279] *Id.*
[280] *See* Farber, *supra* note 248, at 909 (quoting Daniel A. Farber, (quoting Daniel A. Farber, "The Nuclear Regulatory Commission (NRC) has been a prime offender in ignoring uncertainties to reach desired results. Apparently in the belief that a problem is not significant unless it can be precisely quantified, the NRC refuses to discuss the possibility of terrorist attacks on nuclear facilities in its environmental impact statements (EIS) because the risk cannot be quantified").
[281] *Id.*
[282] *See San Luis Obispo Mothers for Peace v. Nuclear Regulatory Comm'n*, 449 F.3d 1016, 1032 (9th Cir. 2006) (explaining that NEPA as interpreted by the 9th

applying conventional risk analysis to nuclear power can lead to a disregard of non-quantifiable risks.[283] To perform risk analysis via conventional methods involves quantification of the risks associated with the activity at issue.[284] This mindset can lead to bias in decision-making and mislead the public about the possible consequences of an activity.[285]

3. A Myopic Mindset in Nuclear Policymaking

When evaluating nuclear power as a solution to global warming, some proponents of nuclear power likewise exhibit myopia with respect to the costs and risks associated with nuclear energy. Specifically, the urgency that some feel regarding the need to reduce GHGs can potentially cause them to under-consider the long-term costs associated with nuclear waste, which remains radioactive and hazardous to humans for hundreds of thousands of years.[286]

Nuclear power as a solution to global warming arguably requires a myopic mindset to seem cost-justifiable. Some policy-makers may consciously adopt this mindset because they care more about their own short-term goals, such as re-election, than about intergenerational long-term threats of harm.[287] Such political myopia can obstruct effective policy making and harm the long-term interests of a citizenry.[288] Government officials can also behave in myopic ways when those who might be harmed by risky activities

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Circuit Court of Appeals, does not allow for the NRC to ignore a risk by simply stating the risk is not quantifiable. The NRC is obligated, under NEPA, to take a "hard look" at the environmental consequences of a terrorist attack if that risk is not insignificant).

[283] *See* Farber, *supra* note 248, at 909.

[284] *See id.* at 910.

[285] *See id.*

[286] See Hindle, *supra* note 251.

[287] *See* Lauren Hartzell-Nichols, *Intergenerational Risks*, *in* HANDBOOK OF RISK THEORY 931, 932 (Sabine Roeser et al., eds. 2012) (describing the one of the challenges of intergenerational risk is that those who may be harmed in the future cannot participate in the regulation of the risky behavior).

[288] *Id.*

are not yet born and hence have no meaningful voice in the present political process.[289]

B. Intergenerational Externality Problems and Nuclear Waste

In addition to the bounded rationality effects highlighted in the preceding subsection, intergenerational externality problems are another possible contributor to the recent resurgence of interest in nuclear energy as a response to climate change. A negative intergenerational externality problem exists when humans take actions that impose significant costs on future generations, but ignore those costs and thus over-engage in the costly activity. It is true that global warming itself is an intergenerational externality problem in that, if the nations of the world fail to adequately slow global warming, its effects will impact future generations. However, to combat global warming with nuclear energy development arguably substitutes one set of intergenerational externalities for another.

The most significant intergenerational externality problem associated with nuclear power relates to the challenge of long-term nuclear waste disposal. There is presently no long-term storage facility for high-level nuclear waste in the United States.[290] In the nuclear fuel cycle, after enriched uranium is processed and used to fuel a nuclear reactor, the spent nuclear fuel that remains stays highly radioactive for hundreds of thousands of years.[291] The U.S. has already generated 75,000 tons of this high-level radioactive waste and its processing byproducts.[292] The radioactive waste is

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[289] *Id.*

[290] *See* Lisa Ledwidge, *If Not Yucca Mountain, Then What? An Alternative Plan for Managing Highly Radioactive Waste in the United States*, *available at* http://ieer.org/resource/commentary/yucca-mountain/ (last updated Apr. 2012) (last visited Mar. 4, 2017) (noting that one of the largest obstacles to utilizing nuclear power is what to do with the high-level waste).

[291] *See* Carfora, *supra* note 163.

[292] *See* Sara Zhang, *The Plan for Storing US Nuclear Waste Just Hit a* Roadblock, WIRED (Jul. 17, 2015, 7:00 AM), *available at* https://www.wired.com/2015/07/plan-storing-us-nuclear-waste-just-hit-roadblock/ (last visited Mar. 4, 2017) (describing the amount of high-level nuclear waste currently being stored in facilities not designed for long-term permanent storage).

currently stored in pools or dry casks at nuclear power plants, whose facilities were never intended for long-term storage.[293] Storing nuclear waste at a plant for an extended period creates a high risk of leaks, and the safest course of action was supposed to be entombing it in a rock formation such as at Nevada's Yucca Mountain, where it would hopefully be inaccessible to future humans.[294] However, strong opposition to the Yucca Mountain facility has caused development plans to stall for so long that the current amount of high-level radioactive waste in the country already exceeds its storage capacity.[295]

Despite the obvious long-term costs of generating more and more radioactive waste, policymakers seem more concerned with being able to meet current energy demands. Meanwhile, this radioactive waste continues to pile up, with no permanent place to go. Its sheer volume and lack of long-term storage capacity for it imposes significant costs on future generations, yet policymakers have little incentive to consider those costs when formulating policy today.

C. Powerful Nuclear Industry Incumbents and Rent-Seeking Behavior

Political rent seeking is yet another possible contributing factor to today's nuclear renaissance worth mentioning. The term rent-seeking behavior usually describes situations when individuals or corporations expend resources to petition the government through paid intermediaries to influence decision-making in ways that financially benefit them.[296] A common example of rent-seeking is

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[293] *See id.*
[294] *See id.*
[295] *See id.*
[296] *See* Vincent R. Johnson, *Regulating Lobbyists: Law, Ethics, and Public Policy*, 16 CORNELL J.L. & PUB. POL'Y 1, 8–9 (2006) (observing the use of paid intermediaries, "lobbyists," to petition the government to influence decision-making of policymakers).

when companies hire government lobbyists to secure policy decisions that benefit the company or harm competitors.[297]

In the context of nuclear power, investor-owned utilities and other nuclear energy industry stakeholders can engage in rent-seeking behavior when they lobby the government to subsidize nuclear power production. For example, entities such as the Koch Industries have recently utilized foundations like the Prosper Foundation, which receives nearly all its funding from another Koch-backed entity, to lobby lawmakers to open the Grand Canyon for uranium mining.[298] If the cost of their lobbying efforts is less than the profits realized from mining uranium in the Grand Canyon, then there exists an incentive to lobby to accomplish this end.[299]

V. PROMOTING A MORE OPTIMAL POLICY APPROACH TO NUCLEAR ENERGY

As outlined above, for a variety of reasons, a growing number of policymakers are arguably under-considering the full societal costs of nuclear energy and are thus increasingly viewing it as a desirable approach to combatting global warming. Meanwhile, multiple other carbon-free energy strategies that are not plagued by such costs seem as a more justifiable means of addressing global warming concerns. Assuming that this is correct, what might federal and state policymakers do to better account for the additional societal costs associated with nuclear energy, as they contemplate energy policies in the coming years? Numerous policy instruments already incentivize renewable energy investments, including tax incentives, production cash subsidies, pricing or tariff mechanisms,

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[297] *See id.* at 9, 10.

[298] *See* Lorraine Chow, *Do the Koch Brothers Want to Mine the Grand Canyon for Uranium?*, ECOWATCH (Apr. 22, 2016, 10:23 AM), https://www.ecowatch.com/do-the-koch-brothers-want-to-mine-the-grand-canyon-for-uranium-1891119890.html ("[a] 'dark money' organization tied to the billionaire Koch brothers is allegedly aiding Arizona politicians' and special-interest groups' efforts to block a bill that would ban uranium mining around Arizona's iconic landmark").

[299] *See id.*

depreciation rules, and renewable portfolio standards.[300] By promoting the growth of the renewable energy over nuclear energy, policymakers can help to correct for the bounded rationality effects and other problems that might otherwise lead to overinvestment in nuclear power in response to climate change.

A. Accounting for Nuclear Energy's Differences in Renewable Portfolio Standards

One possible statutory response to the growing underestimation of nuclear energy costs would be federal legislation that reduces the federal renewable energy tax credits available in states that allow nuclear energy to count toward state renewable portfolio standard (RPS) requirements. Presently, excessive optimism, myopia, intergenerational externality problems, political rent-seeking, and other factors are causing some state policymakers to excessively favor nuclear energy, to the detriment of the renewable energy industry.[301] Adjusting federal tax incentives to discourage such treatment would be one means of addressing this problem. Although the likelihood of the current Republican-controlled Congress enacting such legislation is slim, if the party composition were to change in future years, such legislation could help to curb the treatment of nuclear as being on par with wind and solar.

Tax incentives already do much to promote the growth of renewable energy.[302] As noted above, the federal government has used tax incentives to help new energy technologies enter the market and to be more cost competitive with energy strategies that already have an established presence in the market.[303] One notable federal tax incentive is the production tax credit (PTC) for wind energy. The

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[300] *See* Merrill Jones Barradale, *Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit,* 38 ENERGY POL'Y 7698, 7706 (2010).
[301] *See* Hindle, *supra* note 251.
[302] *See* Mona Hymel, *The United States' Experience with Energy-Based Tax Incentives: The Evidence Supporting Tax Incentives for Renewable Energy,* 38 LOY. U. CHI. L.J. 43, 45 (2006).
[303] *See id.* at 47.

PTC has helped increase wind energy development by significantly reducing its cost.[304] Since 1994, the PTC has led to an increased investment in wind energy of nearly four billion dollars.[305] Similarly, the federal investment tax credit (ITC) for solar energy has been a primary driver of solar energy development.[306]

An RPS is a legislative mandate requiring electricity suppliers, in a given geographical area, to use renewable sources to produce a certain percentage of energy by a given date.[307] RPS policies create an incentive for utility companies to provide their own renewable energy facilities or to purchase renewable energy certificates (RECs) from other renewable energy generators.[308] In combination with federal and state tax incentives, state RPS requirements have contributed to the growth of "renewable generation capacity additions."[309] One recent study estimates that, in 2013, roughly $2.2 billion in benefits from reductions in greenhouse gas emissions and another $5.2 billion from reductions in other air pollution, are attributable to state RPS policies.[310] According to the Lawrence Berkeley National Laboratory, state RPSs have contributed to the development of approximately fifty-six gigawatts of renewable energy.[311] They

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[304] *See id.* at 77.

[305] Ryan Wiser et al., *Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States,* 20 ELECTRICITY J. 77, 80 (2007).

[306] Kevin Porter et al., *Credits and Incentives Provide Green for Going Green*, 25 J. MULTISTATE TAX'N & INCENTIVES 30, 30 (2015).

[307] Benjamin K. Sovacool & Christopher Cooper, *Congress Got It Wrong: The Case for a National Renewable Portfolio Standard and Implications for Policy*, 3 ENVTL. & ENERGY L. & POL'Y J. 85, 90 (2008).

[308] *See id.* at 91.

[309] Daniek P. Krueger & Andrew Begosso, *Mandating Federal Renewables*, 148 PUB. UTIL. FORT. 40, 41–42 (2010).

[310] Steve Capanna, *New Study: Renewable Energy for State Renewable Portfolio Standards Yield Sizable Benefits*, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY (Jan. 7, 2016), https://energy.gov/eere/articles/new-study-renewable-energy-state-renewable-portfolio-standards-yield-sizable-benefits.

[311] EDWARD A. HOLT, THE RPS COLLABORATIVE OF THE CLEAN ENERGY STATES ALLIANCE, THE EPA CLEAN POWER PLAN AND STATE RPS PROGRAMS 1 (2016), https://cesa.org/assets/Uploads/CESA-RPS-CPP-report-May-2016.pdf

are projected to result in up to another fifty gigawatts of new capacity by 2030.[312]

As of 2016, twenty-nine states, the District of Columbia, and three territories, had enacted mandatory RPS policies, and another eight states and one territory had voluntary RPS policies.[313] These plans range from as little as 2 percent of renewable energy generation by 2021, for South Carolina's RPS, to as high as Hawaii's 100 percent renewable energy generation by 2045 RPS.[314] States have the power to adopt RPS through their legal authority to regulate electricity generation within their borders.[315] As stated above, most states' RPS laws require an increasing percentage of electricity sold by utilities to be generated by renewable energy sources over time.[316]

Congress could discourage states from treating nuclear energy as equivalent to renewable energy by requiring that, for their citizens to be eligible for the full federal PTC and ITC, states had to exclude nuclear energy as a qualifying renewable energy source under RPS policies. States that allow nuclear energy to count towards RPS goals would receive either a reduced tax credit or unable to receive any tax credit at all. By refusing to count nuclear energy towards state RPS plans, policymakers are modifying their myopic view of nuclear energy being the short-term solution to global warming by adopting a long-term solution of renewable energy production.

1. Proportionality Goals within RPS Programs

Another potential means of modifying federal tax credit programs to discourage the treatment of nuclear energy as equivalent to renewable energy, under state RPS programs, would be

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[312] *Id.*

[313] Jocelyn Durkay, *State Renewable Portfolio Standards and Goals*, National Conference of State Legislatures (Dec. 28, 2016), http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.

[314] *Id.*

[315] *See* Nolon & Salkin, *supra* note 216, at 150.

[316] *See id.* at 151.

through provisions requiring states to meet specified proportionality goals to be eligible. Six states currently rely on nuclear energy as their main source of electricity generation.[317] In South Carolina and Illinois, over 50 percent of the electricity produced is generated through nuclear energy.[318] If a particular state generates a high proportion of its electricity as nuclear energy, the state might be required to generate at least as much renewable energy as nuclear energy by a specified date, for renewable energy projects within the state to fully receive federal credits. Such provisions could encourage nuclear-heavy states to focus more on adding renewable energy generating capacity and less on propping up nuclear energy generating capacity over time.

2. Discounting Nuclear Energy Credits under RPS Programs

State governments could, similarly, better account for the differences in environmental and other impacts, between nuclear power and renewable energy strategies, by reducing the amount of renewable energy credits or certificates (RECs)[319] available for nuclear energy generation in jurisdictions where nuclear energy is allowed to count toward RPS goals. RECs are considered "tradable commodities" that are characterized as "fungible economic goods that can be traded or sold either bundled with or separate from renewable electricity."[320] States with RPSs have adopted comparable approaches in the past to encourage utility companies to

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[317] *See State Electricity Generation Fuel Shares*, NUCLEAR ENERGY INST. (updated Apr. 2017), https://www.nei.org/Knowledge-Center/Nuclear-Statistics/US-Nuclear-Power-Plants/State-Electricity-Generation-Fuel-Shares.

[318] *See id.* (South Carolina's percentage of electricity produced by nuclear is 55.1 percent; Illinois's percentage of electricity produced by nuclear is 50.1 percent).

[319] RECs are often developed with the hope to create financial incentives for utility companies to invest in renewable energy as opposed to cheaper fossil-fuel sources. *See generally* Michael Gillenwater, *Redefining RECs—Part 1: Untangling Attributes and Offsets,* 36 ENERGY POL'Y 2109, 2110 (2008).

[320] Lori Bird et al., Nat'l Renewable Energy Lab., *Green Power Marketing in the United States: A Status Report (11th Edition)*, 1 (2008) http://www.nrel.gov/docs/fy09osti/44094.pdf.

diversify their electricity production.[321] Utility companies often use RECs as a means to satisfy state RPS goals.[322] For example, if a utility company is required to sell 15 percent of its electricity generated from renewable sources and can only purchase 10 percent on the market, the utility must purchase RECs for the remaining 5 percent. RECs are typically traded on an interstate marketplace, which allows utilities to subsidize the development of renewable energy, as well as meeting state renewable energy purchase requirements.[323] These credits are established when renewable energy producers or other utilities exceed the capacity required by the state.[324] Depending on the state, RECs are categorized in a number of different ways.[325] Despite the differences between how states define RECs, the EPA defines a REC as typically being designated by one megawatt-hour generation of renewable energy.[326]

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321 Nolon & Salkin, *supra* note 216, at 150.

322 *See* Krueger & Begosso, *supra* note 309, at 41–42.

323 *See* Kelly Crandall, *Trust and the Green Consumer: The Fight for Accountability in Renewable Energy Credits*, 81 U. COLO. L. REV. 893, 904 (2010). For specific examples of REC marketplaces *see generally* Green Power Partnership, *Green Power Markets*, U.S. ENVTL. PROT. AGENCY (2017), https://www.epa.gov/greenpower/green-power-markets (providing a list of REC marketers, the renewable resource being sold and prices categorized by national retail REC products and national commercial and/or wholesale REC marketers); *see generally* Green Power Partnership, *Renewable Energy Credit Tracking Systems*, U.S. ENVTL. PROT. AGENCY (2017) https://www.epa.gov/greenpower/renewable-energy-tracking-systems (listing the REC tracking systems for each state in the U.S. and what tracking system each state belongs to).

324 *See* Tomain & Cudahy, *supra* note 47, at 565.

325 *See* Crandall, *supra* note 323, at 913 (providing that the District of Columbia, Maryland, Nevada, New Mexico, North Carolina, Pennsylvania, Texas, Maine and Wisconsin categorize one REC as one unit of production per one MWh generated; Connecticut, Delaware, Florida, Illinois, Massachusetts, Michigan, Minnesota, Montana, North Dakota, Ohio, Oregon, Rhode Island and South Dakota defined one REC as "undefined 'attributes' of renewable generation"; and California, Colorado, New Hampshire, New Jersey and Washington defined one REC as "defined 'attributes' of renewable generation").

326 *See* Green Power Partnership, *Renewable Energy Certificates (RECs)*, U.S. ENVTL. PROT. AGENCY (updated Jul. 15, 2016), https://www.epa.gov/greenpower/renewable-energy-certificates-recs.

State plans could adopt a policy under which RECs generated from renewable energy sources, like solar and wind, received one REC per megawatt-hour of electricity generated, while nuclear energy sources received only half the REC awarded for wind and solar—a 0.5 credit. Such an approach could allow the utility companies to still receive some credit for producing low-emissions energy, but would reflect the greater net social benefit associated with renewable energy sources. The same rule would apply for utility companies purchasing RECs from nuclear energy producers outside of their state.

B. Promoting Renewables-Friendly Updates to the Grid

An alternative way of promoting renewable energy over nuclear power would be through major indirect or direct government investments to improve the nation's electrical grid system. Technically, there is no national power grid in the United States.[327] The electrical grid was built over the course of 100 years and power generation was built originally around communities.[328] The nation's electrical grid has evolved into three large interconnected systems that transport electricity around the country.[329] Given the age of the

[327] *See Electricity Explained How Electricity Is Delivered to Consumers*, U.S. ENERGY INFO. ADMIN. (updated Aug. 31, 2017), http://www.eia.gov/energy explained/index.cfm?page=electricity_delivery [hereinafter Electricity Explained] (providing "Local electricity grids are interconnected to form larger networks for reliability and commercial purposes. At the highest level, the U.S. power system in the Lower 48 states is made up of three main interconnections, which operate largely independent from each other with limited transfers of electricity between them").

[328] *See* Econ. Dev. Research Group, Inc., Am. Soc'y of Civ. Eng'rs, *Failure to Act: The Impact of Current Infrastructure Investment on America's Economic Future,* 19 (2011), http://www.asce.org/uploadedFiles/Issues_and_Advocacy/Our_Initiatives/Infrastructure/Content_Pieces/failure-to-act-economic-impact-summary-report.pdf (mentioning "[c]entralized electric generating plants with local distribution networks were started in the 1880s, and the grid of interconnected transmission lines were started in the 1920s").

[329] The three interconnected electrical systems are the Eastern Interconnection which encompasses the area east of the Rocky Mountains and a portion of Northern Texas, the Western Interconnection which is comprised of fourteen

electrical grid, it is inevitable that some of the existing transmission and distribution lines will need to be replaced or upgraded on a regular basis.[330]

Traditional coal, nuclear, or gas-fired power plants rely on having their resources delivered via truck, rail or pipeline, and are given great flexibility when siting power plants.[331] However, many renewable energy resources, such as wind currents and sunlight, are location-specific and cannot be transported.[332] Because of this, renewable energy must be instantaneously converted into electricity in the precise locations of that resource.[333] A large portion of the world's wind and solar resources are located in sparsely populated areas and are often hundreds of miles away from urban centers. Existing grid systems were not designed to transmit energy over long distances and as such, many renewable energy resources remain untouched.

When policymakers embrace policies that increase the production of nuclear energy instead of updating the electric grid infrastructure to favor renewables, they follow the same trail of path

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western states and extends as far north as British Columbia and Alberta Canada to as far south as Baja California, Mexico, and the Electric Reliability Council of Texas which covers the remaining areas of Texas that are not included in the Eastern Interconnection. *See, e.g.,* Richard J. Kisielowski II, *Hey America! Let's Get Smart: The Need for a Reliable Modern Smart Electrical Grid Resistance to Cyberattacks,* 24 CATH. U. J. L. & TECH 139, 146 (2015); Sara Hoff, *U.S. electric system is made up of interconnections and balancing authorities*, TODAY IN ENERGY, U.S. ENERGY INFO. ADMIN. (July 20, 2016), http://www.eia.gov/todayinenergy/detail.php?id=27152; *2015 State of the Interconnection*, WESTERN ELECTRICITY COORDINATING COUNCIL, *available at* https://www.wecc.biz/Reliability/2015%20SOTI%20Final.pdf; CHRISTOPHER GUO ET AL., RAND CORP., THE ADOPTION OF NEW SMART-GRID TECHNOLOGIES: INCENTIVES, OUTCOMES, AND OPPORTUNITIES, 1, 1 (2015), http://www.rand.org/pubs/research_reports/RR717.html.

330 *See* Electricity Explained, *supra* note 327.

331 *See* Rule, *supra* note 219, at 149.

332 *See* James A. Holtkamp & Mark A. Davidson, *Transmission Siting in the Western United States: Getting Green Electrons to Market*, 46 IDAHO L. REV. 379, 381 (2010).

333 *See* Sandeep Vaheesan, *Preempting Parochialism and Protectionism in Power,* 49 HARV. J. ON LEGIS. 87, 97 (2012).

dependence as their predecessors. The phenomenon of inertia and path dependence transcends through history.[334] One notable inertia example analogous to today's energy market is the mindset of whalers in the nineteenth century. Few whalers in that era believed that kerosene would one day replace whale oil as a fuel source. Through the implementation of new grid technologies, policymakers will be able to break away from this path dependence mindset. Similarly, like the pony express of the nineteenth-century and the telegraph system that replaced it, today's outmoded electrical grid, built for centralized power generation, will inevitably be replaced by newer technologies.[335]

In addition to creating new transmission-related challenges, wind and solar energy also suffer from intermittency limitations that could be mitigated through updates to the grid. The current electrical grid is managed by balancing authorities, who manage the flow of electricity, to ensure that the electricity supply exactly matches demand.[336] If the electrical supply is higher or lower than the demand is for too long, portions of the grid can shut down and create a blackout.[337]

A valuable potential means of mitigating both challenges is to increase government-provided incentives to update the grid, either through the updating of transmission lines or through greater integration of smart grid technologies. One proposed effort toward this goal would be the development of a new "backbone" system of

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[334] Newer technologies often threaten to displace older, obsolete technologies, although at the time, people don't quite readily believe that. This idea is prevalent throughout history. For more recent examples of technologies rendered obsolete, see generally George Dvorsky, *22 Obsolete Technologies That People Thought Would Last Forever*, GIZMODO (Feb. 20, 2014, 1:00 PM), http://io9.gizmodo.com/25-obsolete-technologies-that-future-generations-will-n-1526922030 (the author notes "[w]e live in an era of accelerating technological change, and with it, accelerated rates of obsolescence").

[335] *See* Rule, *supra* note 219, at 167.

[336] *See* Glen Andersen, *Integrating Renewable Energy,* NAT'L CONFERENCE OF STATE LEG. (2016), http://www.ncsl.org/research/energy/integrating-renewable-energy.aspx.

[337] *See* Emmett Pepper, *Time-of-Use Pricing Could Help China Manage Demand*, 11 SUSTAINABLE DEV. L. & POL'Y 18, 18 (2010).

extra high-voltage lines across the Midwest region of the country, where the majority of wind resources are located. This system would enable large amounts of electricity, generated by remote wind resources, to be delivered to population centers along the east and west coasts. Even upgrading just the country's high-voltage transmission lines with "smart" devices, which would cost between $56 billion and $64 billion, would help to mitigate the intermittency and variability challenges of renewable energy discussed below.[338]

Updating transmission lines in coastal states might also better promote renewable energy and discourage continued reliance on nuclear power. Roughly 78 percent of the electricity consumed each year in the U.S. is used in the twenty-eight coastal states.[339] Relatively little new transmission infrastructure would be needed to deliver off-shore wind energy to these states.[340] By focusing on off-shore wind, the need for additional transmission lines to deliver power from remote parts of the country to coastal states would be reduced.[341]

In addition to improving the nation's electricity transmission infrastructure, government subsidies and expenditures aimed at updating the grid with smart features[342] could further promote renewable energy and slow the nuclear renaissance as well. Upgrades to the grid have the potential to allow power to be used and produced more efficiently by allowing two-way communication

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338 Paul L. Joskow, *Creating a Smarter U.S. Electricity Grid*, 26 J. ECON. PERSPECTIVES 29, 35–36 (2012).

339 U.S. DEP'T OF ENERGY, 20% WIND ENERGY BY 2030: INCREASING WIND ENERGY'S CONTRIBUTION TO U.S. ELECTRICITY 1, 48 (2008), http://www.nrel.gov/docs/fy08osti/41869.pdf.

340 *See* Erica Schroeder, *Turning Offshore Wind On*, 98 CAL. L. REV. 1631, 1640 (2010).

341 *See* Rule, *supra* note 219, at 166.

342 Sarah A.W. Fitts & Geraldine Kim, *Renewable and Distributed Energy Resources 2009 Annual Report*, 2009 A.B.A. SEC. ENV'T, ENERGY, & RES. 319 (A "Smart Grid" is the "application of advanced digital technologies" that are "intended to improve the reliability, security . . . and efficiency of the . . . grid, while reducing environmental impacts and promoting economic growth.").

between a utility and its customers.[343] Such smart grid technologies could help make it easier to integrate energy technologies capable of helping displace fossil fuel combustion as a source of energy.[344]

Smart grid updates and energy storage technologies[345] are needed to better integrate intermittent renewable energy resources like wind and solar.[346] Energy storage devices hold electricity generated during low demand for dispatch during high demand times or when transmission line capacity is freed up.[347]

In conjunction with smart grid technologies, energy storage innovations are already beginning to contribute to the growth of renewable energy by improving grid reliability and ensuring efficient production.[348] Traditionally, when there is high demand for

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343 *See* Bobby Magill, *This Is How the U.S. Power Grid Works*, CLIMATE CENTRAL (Nov. 25, 2014), http://www.climatecentral.org/news/how-the-us-power-grid-works-18378.

344 Samantha Ruiz et al., *Promoting Clean Reliable Energy Through Smart Technologies and Policies: Lessons from Three Distributed Energy Case Studies*, 6 SAN DIEGO J. CLIMATE & ENERGY L. 39, 55 (2014–2015).

345 *See* Third-party Provision of Ancillary Service; Accounting and Financial Reporting for New Electric Storage Technologies, 78 Fed. Reg. 46,177, 46,202 (Jul. 30, 2013) (to be codified at 18 C.F.R. pts. 35, 101) (according to the Federal Energy Regulatory Commission, energy storage is defined as "property that is interconnected to the electrical grid and is designed to receive electrical energy, to store such electrical energy as another energy form, and to convert such energy back to electricity and deliver such electricity for sale, or to use such energy to provide reliability or economic benefits to the grid"); MATTHEW DEAL ET AL., CAL. PUB. UTILS. COMM'N, ELECTRIC ENERGY STORAGE: AN ASSESSMENT OF POTENTIAL BARRIERS AND OPPORTUNITIES 1, 2–3 (2010), https://jointventure.org/images/stories/pdf/cpuc.storagewhitepaper7910.pdf ("[Electric energy] storage can be defined as: a set of technologies capable of storing previously generated electric energy and releasing that energy at a later time. EES technologies may store electrical energy as potential, kinetic, chemical, or thermal energy, and include various types of batteries, flywheels, electrochemical capacitors, compressed air storage, thermal storage devices, and pumped hydroelectric power.").

346 *See* EXEC. OFFICE OF THE PRESIDENT, ECONOMIC BENEFITS OF INCREASING ELECTRIC GRID RESILIENCE TO WEATHER OUTAGES, 14 (2013), https://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.

347 Amy L. Stein, *Reconsidering Regulatory Uncertainty: Making a Case for Energy Storage*, 41 FLA. ST. U. L. REV. 697, 705 (2014).

348 *See generally id.* at 709–16 (discussing the economic, efficiency, and environmental benefits of energy storage).

electricity, grid operators have relied on peaker plants[349] to ramp up production to satisfy the increased demand. Energy storage solutions have the potential to displace fossil-fuel generating peaker plants by administering the stored energy to the grid during high-demand periods, eliminating the need to ramp up production at peaker plants.[350]

CONCLUSION

As the effects of climate change continue to manifest themselves through increasingly severe weather events, droughts, and rising temperatures, the urgency to minimize greenhouse gases to arrest global warming is mounting. In their zeal to address these challenges, some policymakers have begun to advocate for nuclear energy development as a primary means of addressing them. Due in part to excessive optimism, myopia, path dependence, intergenerational externalities, or a willingness to serve government rent-seekers, advocates of this mindset have catalyzed a controversial nuclear renaissance in the U.S. in recent years. Some have even begun treating nuclear energy as being equivalent to renewable energy strategies such as wind and solar energy in the formation of energy policy. Such treatment under-accounts for the unique environmental and societal costs associated with nuclear power.

Fortunately, there are policy strategies that can better ensure that stakeholders and actors in the energy industry account for the unique costs of nuclear power in their behavior. Among other things, various potential changes to federal tax credit policies and state RPS programs could better reflect these costs. Targeted investments in the nation's grid infrastructure could, likewise, enable the nation to move toward a more carbon-free future without

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[349] *See* William Boyd & Ann E. Carlson, *Accidents of Federalism: Ratemaking and Policy Innovation in Public Utility Law*, 63 U.C.L.A. L. REV. 810, 871 (2016) (defining a "peaker plant" as a "plant that can be brought on line relatively quickly").

[350] Statement of the Electricity Storage Association, *Centralized Capacity Markets in Regional Transmission Organizations and Independent System Operators,* FERC Docket No. AD13-7-000 (Sept. 11, 2013).

heavy investments in nuclear power, and the additional risks and costs that such investments would bring. Through these and other changes, policymakers can help to slow global warming, while still sparing future generations from additional risks and hazards associated with expanded reliance on nuclear power.