NUCLEAR ENERGY FOR THE TABLE, PLEASE

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Introduction

When you hear the word "nuclear," what comes to mind is likely the image of a bright green, viscous liquid; or maybe you see Homer Simpson squirrelly working at the Springfield nuclear power plant. When you hear the word "energy," you likely think of that feeling you try to achieve through countless cups of coffee throughout the workday. Separately, these words are innocent enough; together, not so much. Fears of nuclear meltdowns, radiation, and a generation of people with three arms and fifteen toes live rent-free in many people's imaginations. The environment, however, would benefit from a societal paradigm shift to see nuclear energy for what it is: An energy option worth investing in.

At COP21[1] in 2015, the international community adopted a legally binding treaty on climate change, better known as the Paris Climate Agreement [hereinafter Paris Agreement].[2] The Paris Agreement was monumental for climate change efforts, coming a long way to extinguish the controversies surrounding Al Gore's climate change crisis warning in *"An Inconvenient Truth."*[3] With the Paris Agreement came a goal-setting process that binds nations under the common cause of combating global warming by lowering greenhouse gas emissions as soon as possible, and

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[1] "The [Conference of the Parties] is the supreme decision-making body of the [U.N. Framework Convention on Climate Change]. All States that are Parties to the Convention are represented at the COP, at which they review the implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention." *Conference of the Parties (COP)*, UNFCCC (n.d.), *available at* https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop (last visited Jan. 16, 2023).

[2] *COP 21*, UNFCCC (n.d.), *available at* https://unfccc.int/event/cop-21 (last visited Jan. 16, 2023).

[3] Al Gore's warning on the effects of climate change were viewed by many as politically motivated; people saw it as him setting up a platform to run for president again. Many Americans discredited the science behind climate change, and the world lost valuable time to heed the impending dangers. *See* Peter S. Canellos, *Gore's Ecology Film Gets An 'Inconvenient' Label of Liberalism*, THE BOS. GLOBE (June 6, 2006), *available at* http://archive.boston.com/news/nation/articles/2006/06/06/gores_ecology_film_gets_an_inconvenient_label_of_liberalism/ (last visited Jan. 16, 2023).

helping one another to do so.[4] Nearly a decade out from the birth of this agreement, and the very goals set forth are at risk of falling apart.[5] Scientists suspect that financial assistance for climate efforts, water security, and food systems will all worsen at the current warming rate, which will lead to tension within and across borders.[6] Additionally, a warmer planet will cause more intense heat waves, wildfires in areas that do not have the infrastructure to combat them, and rising sea levels causing coastal city flooding and species extinctions.[7] In order to address these horrifying outcomes, daring solutions should be encouraged.

Please welcome to the table: Nuclear energy. Why on Earth should the international community reinvest in nuclear energy? It is expensive,[8] people fear nuclear waste and the effects of radiation,[9] and countries have been decommissioning nuclear power plants for years.[10] Plus, renewable energy technologies, such as wind, solar, and hydro-power, can fix climate change right now, so why go backwards with technology, right? Wrong. Nuclear energy is the cleanest, most efficient energy on the market,[11] and although renewable energy has grown significantly during the twenty-first century, there are significant roadblocks for full renewable reliance.

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[4] *The Paris Agreement*, UNFCCC, *available at* https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (last visited Jan. 16, 2023).

[5] *See World is off track to meet Paris Agreement Climate Targets*, U.N. ENV'T PROGRAMME (Sept. 16, 2021), *available at* https://unepccc.org/world-is-off-track-to-meet-paris-agreement-climate-targets/ (last visited Jan. 16, 2023).

[6] *See United in Science 2021*, U.N. ENV'T PROGRAMME (Sept. 16, 2021), *available at* https://library.wmo.int/doc_num.php?explnum_id=10794 (last visited Jan. 16, 2023).

[7] *See Climate Change and International Responses Increasing Challenges to U.S. National Security Through 2040*, NAT'L INTEL. COUNCIL (Oct. 21, 2021), *available at* https://www.dni.gov/files/ODNI/documents/assessments/NIE_Climate_Change_and_National_Security.pdf (last visited Jan. 16, 2023).

[8] *See generally Status Report 2021*, WORLD NUCLEAR INDUS. STATUS REP., *available at* https://www.worldnuclearreport.org/IMG/pdf/wnisr2021-lr.pdf (last visited Jan. 16, 2023).

[9] *Why America is Scared of Nuclear, But Shouldn't Be*, CONSERVAMERICA (Oct. 18, 2019), *available at* https://www.conservamerica.org/latest-news/why-america-is-scared-of-nuclear-but-shouldnt-be (last visited Jan. 16, 2023).

[10] Stuart Braun, *Nuclear Melts Down Ahead of Climate Summitt,* DEUTSCHE WELLE (Sept. 28, 2021), *available at* https://www.dw.com/en/world-nuclear-industry-status-report-climate-renewables/a-59338202 (last visited Jan. 16, 2023).

[11] *Fundamentals: Nuclear Provides Carbon-Free Energy 24/7*, NUCLEAR ENERGY INST., *available at* https://www.nei.org/fundamentals/nuclear-provides-carbon-free-energy (last visited Jan. 16, 2023).

Proceeding in five parts, this paper addresses the value of reinvesting in nuclear energy, and why continuing nuclear power plant decommissioning is harmful for international climate objectives. In Part I, this paper provides the background on nuclear energy use across the planet, as well as where the international community stands on meeting climate objectives under the Paris Agreement. In Part II, this paper addresses the concerns surrounding nuclear energy. In Part III, this paper analyzes why renewable energy alternatives are not ready to, and simply cannot, take over as the primary energy source for power grids. This includes assessing a rapidly growing global power demand, energy grid issues, productivity concerns, and the lack of land for renewable technologies to call home. In Part IV, this paper addresses the environmental value in expanding nuclear energy investment. This includes a discussion on how nuclear divestment leads to an erasure of existing environmental gains, and how nuclear energy will assist in closing the energy gap currently plaguing international climate objectives. Finally, in Part V, this paper offers how the international community can pursue nuclear reinvestment through utilizing license extensions, and investing in new nuclear technologies. Investment in nuclear energy will help the international community get closer to the path that climate change mitigation must be on if there stands a chance to prevent the horrifying effects of climate change.

I. Nuclear Energy and the Current Climate Crisis

Countries vary significantly in the amount that they rely on nuclear energy.[12] This reflects different sentiments that countries and their people have toward imagining nuclear power as part of their energy future. The over-arching trend is that the use of nuclear energy is waning, and countries are seeking alternatives.[13] At the same time, the climate objectives deemed necessary, under the Paris Agreement, to avoid irreparable harm to the planet are in dire straits.

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[12] *See generally* Hannah Ritchie ET AL., *Nuclear Energy*, Our World in Data (2020), *available at* https://ourworldindata.org/nuclear-energy (last visited Jan. 16, 2023).

[13] *Nuclear Power in a Clean Energy System*, INT'L ENERGY AGENCY 1, 3-4 (May 2019), *available at* https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system (last visited Jan. 16, 2023).

A. THE HISTORY OF NUCLEAR ENERGY

Nuclear is the ugly duckling of the energy sector; perceived by many as unattractive and dangerous, but underneath, it holds the key to a beautiful, carbon-free energy future. Nuclear power plants operate in thirty-two countries, and account for meeting slightly more than ten percent of the world's energy demands.[14] In total, there are about 440 nuclear power reactors that operate practically year-round to provide electricity to those countries, and to countries without nuclear power plants that choose to import nuclear energy.[15] In order to construct and operate nuclear power plants, it takes a global effort. For example, a nuclear reactor built in China likely contains components constructed in South Korea, Canada, or Germany, and utilizes uranium from Australia or Namibia.[16] As mentioned, the amount that a country relies on nuclear power varies around the world. In 2020, nuclear energy generated 19.7% of electricity in the U.S., a whopping 70.6% of electricity in France, but only 4.9% of electricity in China.[17]

What also varies are countries' opinions on the role of nuclear power in their respective energy futures. In the U.S., the plan is to continue decommissioning nuclear power plants. During the second half of the last decade, the U.S. federal government closed ten nuclear power plants, representing about ten percent of the nuclear fleet.[18] The majority of those were closed before the end of their licensed periods, which the government justified due to high operating costs.[19] Similarly, many European countries are not interested in ramping up nuclear investments. For example, Germany, Denmark, and Spain are pushing back on efforts by other European nations—led by France—to include more nuclear power in the green energy future within the E.U.[20] Germany has long had

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[14] Ritchie ET AL., *supra* note 12.
[15] *Id.*
[16] *See id.*
[17] *Id.*, at illus. 4.
[18] *Nuclear Explained: U.S. Nuclear Energy*, ENERGY INFO. ADMIN. (Apr. 6, 2021), *available at* https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php (last visited Jan. 16, 2023).
[19] Lois Parshley, *The controversial future of nuclear power in the U.S.*, NAT'L GEOGRAPHIC (May 4, 2021), *available at* https://www.nationalgeographic.com/environment/article/nuclear-plants-are-closing-in-the-us-should-we-build-more (last visited Jan. 16, 2023).
[20] Liz Alderman & Stanley Reed, *Europe Revisits Nuclear Power as Climate Deadlines Loom*, THE N.Y. TIMES (Nov. 29, 2021), *available at*

plans to phase out nuclear energy reliance starting around 2022,[21] primarily in response to the Fukushima meltdown in Japan in 2011, and their desire to increase reliance on renewable energy systems.[22] China, on the other hand, has a much more optimistic outlook on increasing nuclear energy use as part of their clean energy future. As the world's largest carbon dioxide [hereinafter CO_2] emitter, China plans to build at least 150 new reactors in the next fifteen years, with their eyes on outsourcing that energy to other nations, as well.[23] Although China, as a major polluter, is optimistic about the future of nuclear energy in meeting their international climate goals, other major polluters remain hesitant.

Nuclear energy usage worldwide decreased by nearly 4% between 2019 and 2020[24] and for now that same trend appears to continue with further retirements inevitable. The reasons behind nuclear energy hesitancy center around public fear of radiation, government regulations that make nuclear energy expensive,[25] nuclear waste concerns, and cross-border contamination in the event of an accident.[26] Proponents of continued nuclear energy investments are looking toward Small Modular Reactors [hereinafter SMRs] as safer and cheaper nuclear alternatives that do not sacrifice the inherent efficiency of nuclear power.[27] This alternative is thought to be easier to build and install than the large nuclear reactors that are used in current power plants.[28] There is optimism that SMRs can be lent to countries with less experience in the nuclear energy

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https://www.nytimes.com/2021/11/29/business/nuclear-power-europe-climate.html (last visited Jan. 16, 2023).

[21] Ritchie ET AL, *supra* note 12.

[22] Judy Dempsey & Jack Ewing, *Germany, in Reversal, Will Close Nuclear Plants by 2022*, THE N.Y. TIMES (May 30, 2011), *available at* https://www.nytimes.com/2011/05/31/world/europe/31germany.html?searchResultPosition=9 (last visited Jan. 16, 2023).

[23] Dan Murtaugh & Krystal Chia, *China's Climate Goals Hinge on a $440 Billion Nuclear Buildout*, BLOOMBERG (Nov. 2, 2021), *available at* https://www.bloomberg.com/news/features/2021-11-02/china-climate-goals-hinge-on-440-billion-nuclear-power-plan-to-rival-u-s (last visited Jan. 12, 2023).

[24] *Nuclear Power in a Clean Energy System*, *supra* note 13.

[25] *See* Samuel Miller McDonald, *Is Nuclear Power Our Best Bet Against Climate Change*, BOSTON REVIEW (Oct. 12, 2021), *available at* https://bostonreview.net/science-nature/samuel-miller-mcdonald-nuclear-power-our-best-bet-against-climate-change (last visited Jan. 12, 2023).

[26] Alderman & Reed, *supra* note 20.

[27] *Id.*

[28] *4 Key Benefits of Advanced Small Modular Reactors*, Off. of Nuclear Energy (May 28, 2020), *available at* https://www.energy.gov/ne/articles/4-key-benefits-advanced-small-modular-reactors (last visited Jan. 12, 2023).

market[29] thereby allowing faster worldwide implementation and reliance, not just production in countries that already have the appropriate technologies and infrastructure.

Utilizing nuclear power brings plenty of benefits to justify sustaining investments and implementing SMRs in future clean energy initiatives. First, nuclear power plants help to keep power grids stable because they can adjust their operations to meet demand changes.[30] This is important in instances of natural disasters, changing seasons, and growing populations, to prevent energy surges or energy losses. Second, currently operating nuclear reactors can operate (safety permitting) beyond their initial functional lives, often by multiple decades.[31] This benefits the energy sector by extending the use of a clean energy source without requiring the heavy time and money investment to construct new nuclear power plants using old reactor technologies.[32] In conjunction with extending operating licenses, investing in SMRs appears to be a cheaper alternative to constructing large-scale nuclear reactors, while lending a hand to expanding nuclear energy systems. Third, continuing nuclear power production buys time for the renewable energy sector to advance technologically without placing too large of a burden on power grids or the existing renewable energy market. At present, cutting out nuclear energy would require countries to further invest in fossil fuels since renewable energy technologies have not yet developed enough to handle the inevitable rise in energy demands.[33] Fourth, expanding nuclear energy investments has the potential to close the emissions gap by furthering the environmental gains already realized by utilizing nuclear energy.[34] Abandoning nuclear energy would be a critical mistake. If done, the cumulative CO_2 emissions are projected to rise by four billion tons over the next twenty years.[35] France recognized this reality and, in 2015, decided to push back their nuclear energy reduction plans by ten years because they feared rising CO_2 emissions.[36] Now, France is part of the group of European countries that are looking to

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[29] *See id.*
[30] *Nuclear Power in a Clean Energy System*, *supra* note 13.
[31] Office of Nuclear Energy, *What's the Lifespan for a Nuclear Reactor? Much Longer Than You Might Think*, U.S. Dep't. of Energy (Apr. 12, 2020), *available at* https://www.energy.gov/ne/articles/whats-lifespan-nuclear-reactor-much-longer-you-might-think (last visited Jan. 12, 2023).
[32] *Nuclear Power in a Clean Energy System*, *supra* note 13, at 4.
[33] *See id.*
[34] *Supra* note 13, at 4.
[35] *Id.*
[36] *Nuclear Power in a Clean Energy System*, *supra* note 14.

expand nuclear energy investments and integrate it into clean energy initiatives in the face of large-scale, global failure to meet international climate change goals.[37] It will be critical for the world's largest CO_2 polluters to recognize the value in reversing course on nuclear decommissioning as a way to meet the critical deadlines set forth in international climate treaties and agreements.

As of now, "around one-quarter of the current nuclear capacity in advanced economies is set to be shut down by 2025."[38] With this problematic move comes an important question: Has the international community quietly given up on saving the planet? Unfortunately, it feels that way. Without nuclear energy in the mix, a clean energy future, and keeping the Earth from dangerous warming, seem to be increasingly difficult mountains to climb.

B. THE CURRENT STATE OF CLIMATE CHANGE

On Earth Day 2016, the Paris Agreement opened for signature; entering force that November.[39] The agreement sets out ambitious climate change goals. Notably, the agreement seeks to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and [to pursue] efforts to limit the temperature increase to 1.5°C above pre-industrial levels" as a way to reduce the impacts of climate change.[40] The goal remains to significantly reduce carbon emissions by 2030, and to reach a net-zero emissions by mid-century.[41] Unfortunately, the failure alarm bells have already begun to ring.

As of the autumn of 2021, greenhouse gases in the atmosphere continue to rise at record levels, which is the largest indicator of future warming.[42] According to the United in Science 2021 Report, "there is an increasing likelihood that temperatures will temporarily breach the threshold of 1.5°C above the pre-industrial era in the next five years."[43] This means that the chance that global temperature will go above the end-of-century goal within the next five years is ever-increasing. This is a direct threat not only to climate targets, but to all living species and the

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[37] Alderman & Reed, *supra* note 20.
[38] *Nuclear Power in a Clean Energy System*, *supra* note 13.
[39] *The Paris Agreement*, U.N., *available at* https://www.un.org/en/climatechange/paris-agreement (last visited Jan. 24, 2023).
[40] Paris Agreement to the United Nations Framework Convention on Climate Change, art. 2(1)(a), Dec. 12, 2015, T.I.A.S. No. 16-1104.
[41] *The Paris Agreement*, *supra* note 4.
[42] *World Is Off Track to Meet Paris Agreement Climate Targets*, *supra* note 5.
[43] *United in Science 2021*, *supra* note 6.

environment; a threat that is unique to the present. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, over the last two decades, global surface temperatures are nearly 1°C warmer than in 1850.[44] In the last decade, that number increased to about 1.1°C, but about 1.6.C° over land.[45] According to the report, it is more likely than not that human conduct has increased greenhouse gas concentrations which has led to more polar ice melting, heat waves, hurricanes and cyclones, and droughts.[46] These events have implications for coastal communities, species living on those coasts, global economies, and international security.

The U.S. intelligence community had stated that failure to meet global climate goals, as the world is set to do, will worsen geopolitical tensions, aggravate social stability, and cause an increase in the need for humanitarian aid.[47] Amongst the concerns, the National Intelligence Council identifies several key issues that will likely worsen. The need for financial and technological assistance for developing countries is currently rated a medium-level concern but by the end of the decade, the report projects this to be a high-level concern.[48] Additionally, cross-border water tensions and conflicts are currently rated as a low-level concern but by 2040, the intelligence community expects it to be a high-level concern.[49] Further, the strain on energy and food systems are a low-level concern but by 2040, it is expected to be a high-level concern.[50] In order to change these projections, "global emissions would have to drop sharply in the next decade and reach net zero by 2050" to change course on the international community's inevitable failure to limit warming to 1.5 C° above pre-industrial levels.[51] The impacts that global warming pose to human security because of these worsening issues are concerning. According to the report, more frequent and intense heat waves will impact

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[44] *Climate Change 2021: The Sixth Assessment Report*, UNIPCC at 5 (Aug. 7, 2021), *available at* https://www.ipcc.ch/report/ar6/wg1/#FullReport (last visited Oct. 18, 2022).

[45] *Id.*

[46] *See id.*

[47] Christina Pazzanese, How Climate Change Will Impact National Security, THE HARVARD GAZETTE (Nov. 24, 2021), available at https://news.harvard.edu/gazette/story/2021/11/how-climate-change-will-impact-national-security/ (last visited Oct. 18, 2022).

[48] *Climate Change and International Responses Increasing Challenges to U.S. National Security Through 2040*, *supra* note 7.

[49] *See id.*

[50] *See id.*

[51] *Id.* at 1.

labor productivity, wildfires, and human health.[52] More frequent and longer droughts will threaten food supplies, drive migration, and impact border security of wealthier and more secure nations.[53] Further, if Arctic ice continues to melt faster with the rising global temperatures, ocean circulation and salinity will be impacted, which will burden ocean and lake ecosystems, increase competition to trade routes, endanger coastal cities because of more dramatic storm surges, and threaten species' existence.[54] Each of these consequences will have a chain-reaction impact on trophic systems, which will worsen food and health security all the way up to humans, regardless of nationalities or borders.

Since the passage of the Paris Agreement, the emissions gap is larger than ever.[55] The emissions gap is the difference between projected emissions under current climate commitments, and the emission levels necessary to meet the goals of the Paris Agreement.[56] This indicates that current policies are missing the mark, and without large-scale decarbonization efforts, the Paris Agreement will be rendered useless. All of the aforementioned human security issues outlined in the U.S. intelligence community's report are more likely than not to occur, unless drastic changes are made in climate change mitigation plans.[57] Current climate mitigation plans are doomed to fail, and although high-polluter nations seem hard-pressed to make a change, they have yet to commit to the meaningful and necessary changes to keep their goals realistic. In the fall of 2021, at COP26, the international community reaffirmed their commitment to the objectives of the Paris Agreement, including phasing out fossil fuels,[58] one of the worst polluters for increasing global temperatures. While this commitment is important, it ignores the insufficiencies in present-day renewable energy capabilities. In 2019,

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[52] *Id.* at 2.
[53] NAT'L INTELLIGENCE COUNCIL, *supra* note 7.
[54] *Id.*
[55] U.N. ENV'T PROGRAMME, *supra* note 6.
[56] UNEP Copenhagen Climate Centre, *Emissions Gap Report 2021*, U.N. ENV'T PROGRAMME at 29 (Oct. 26, 2021), *available at* https://www.unep.org/resources/emissions-gap-report-2021 (last visited Jan. 16, 2023).
[57] NAT'L INTELLIGENCE COUNCIL, *supra note 7.*
[58] Alice Hill & Madeline Babin, *What COP26 Did and Didn't Accomplish*, COUNCIL ON FOREIGN RELATIONS (Nov. 15, 2021), *available at* https://www.cfr.org/in-brief/cop26-climate-outcomes-successes-failures glasgow?gclid=CjwKCAiA7dKMBhBCEiwAO_crFPnO-b6_IqeNu_rhocJ80VnTJQHf (last visited Jan. 16, 2023).

electricity generation made up 25% of all greenhouse gas emissions.[59] That is not a menial number. Almost all of those emissions come from fossil fuels, with fossil fuels making up about 62% of all electricity generation.[60] In order to meet climate goals, and to make significant changes to greenhouse gas pollution, countries must look to feasible and realistic solutions. Giving up on nuclear energy, as countries around the world are doing, is unwise. The role of nuclear energy moving forward is doomed if people continue to believe that renewables are well-positioned to fully replace all other energy sources. That position poses grave consequences to climate objectives because under those circumstances, fossil fuel reliance is only slated to rise, and all progress made on reducing greenhouse gases would be effectively erased.

II. The Risks of Nuclear Energy INVESTMENT

Nuclear energy must be part of the clean energy transition. In order to do so, the hazards of nuclear energy investment must be dissected. First, nuclear energy production comes with high operating costs that tend to drive away investors. Second, there are regulatory risks associated with continued operation of nuclear power plants. Third, nuclear energy creates waste that could be difficult to dispose of. Fourth, concerns about nuclear meltdowns and weapons impact public perception and investment. Fifth, nuclear energy skeptics do not believe that SMRs are even useful in the clean energy transition. Each of these concerns must be neutralized.

A. HIGH OPERATING COSTS

A first concern about nuclear energy is the high operating cost of continued investment. To determine the cost of an energy source over its lifetime, economists look to calculate the levelized cost of electricity [hereinafter LCOE]. LCOE is the calculation of the "present value of the total cost of building and operating a power plant over [its] lifetime," which is also referred to as the cost per megawatt hour [hereinafter MWh].[61] Nuclear energy is the most expensive energy source. From 2009 to 2020, the cost of nuclear energy has increased from $123/MWh

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[59] *Sources of Greenhouse Gas Emissions,* U.S. ENV'T PROT. AGENCY (July 27, 2021), *available at* https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions (last visited Jan. 16, 2023).
[60] *Id.*
[61] DOE Office of Indian Energy, *Levelized Cost of Energy (LCOE)*, U.S. DEPT. OF ENERGY at 3 (Aug. 2015).

to $163/MWh.[62] Compared to other energy sources, the price tag of nuclear energy looks pretty unattractive. Over the same time period, the price of coal has remained stable, only increasing one dollar to $112/MWh.[63] On the other hand, the price of renewables has decreased between 2009 and 2020. Solar energy has decreased from $359/MWh to $37/MWh, and wind energy has decreased from $135/MWh to $41/MWh.[64]

Unfortunately for the nuclear energy industry, as renewables have gotten cheaper, nuclear energy has gotten more expensive, with projections forecasting further increases.[65] Driving these high costs are public perception and government regulations.[66] Fossil fuels make nuclear energy look expensive because governments are not doing enough to make fossil fuels unattractive; thus, investors hesitate to invest, supplies become more expensive, and so on. Carbon taxes across the world have been historically low or non-existent.[67] As of the end of 2021, countries that collectively represent 54% of greenhouse gas emissions[68] do not have federal-level carbon taxes to deter investment in or use of the fossil fuels.[69] This allows governments to manipulate prices to make nuclear power more expensive when compared to fossil fuels; thereby giving investors an incentive to avoid nuclear energy and ultimately fulfilling the governments' objective to move away from nuclear power. Economists have found that low CO_2 prices in the U.S. make nuclear power plants too expensive to operate, yet conversely, high CO_2 prices in Europe makes nuclear energy competitive.[70] For example, high CO_2 prices induced by bold carbon taxes have increased the cost of coal by about $23 across Europe,[71] leveling nuclear power prices.

In order to address high operating costs, governments around the world must adopt aggressive carbon taxes to deter fossil fuel investment,

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[62] *Status Report 2021 supra* note 8.
[63] World Nuclear Industry Status Report, *supra* note 8, at 293.
[64] World Nuclear Industry Status Report, supra note 8, at 293.
[65] Miller-McDonald, *supra* note 25, at 8.
[66] *See* Nuclear Power in Clean Energy System, *supra* note 13, at 4.
[67] *See* Nuclear Power in Clean Energy System, *supra* note 13, at 40.
[68] *Greenhouse Gas Emissions by Country 2021*, WORLD POPULATION REV., *available at* https://worldpopulationreview.com/country-rankings/greenhouse-gas-emissions-by-country (last visited Jan. 16, 2023), (the referenced countries are China, the U.S., India, and Russia).
[69] *Carbon Pricing Dashboard*, The World Bank, *available at* https://carbonpricingdashboard.worldbank.org/map_data (last visited Jan. 16, 2023).
[70] *See,* Nuclear Power in Clean Energy System *supra* note 13, at 41-45.
[71] Nuclear Power in Clean Energy System *supra* note 13, at 45.

and to level the playing field for continued investment in an environmentally valuable energy like nuclear power. This is important to put international climate commitments into action by deterring investment in energies that will prevent the international community from meeting the Paris Agreement goals.

B. REGULATORY HURDLES

A second concern about nuclear energy comes in the form of regulatory hurdles. The National Environmental Policy Act [hereinafter NEPA] requires federal agencies to assess environmental impacts of federal actions through environmental impact statements.[72] Consequently, the Nuclear Regulatory Commission [hereinafter NRC], a federal agency, is required to consider all environmental impacts of extending licenses for nuclear power plants when an extension is requested.[73] This process ensures that the NRC is considering pertinent environmental concerns, and that they can act in the best environmental interests, giving them discretion to shut down nuclear power plants that are environmentally consequential.[74]

When seeking a license extension, applicants must describe the impacted area around the plant, how any modifications they make or plan to make affect the environment, and any future activities at the plant that may impact the environment.[75] As is the case for almost all existing power plants, when seeking a license renewal, the plants are exempt from conducting plant-specific severe accident mitigation analyses, so long as one is on the record,[76] which eases the regulatory process slightly. However, the public and interest groups retain the ability to stall the process. Upon request of any interested person, the NRC must grant a hearing to address and mitigate any issues raised.[77] Interested parties can stall the re-licensing process of an otherwise properly and safely operating power plant, through lengthy and heavy public comment periods, and forcing extensive evidentiary hearings on the challenges they bring.[78]

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[72] Nat'l Env't Policy Act, 42 U.S.C. §§ 4321-4347 (1962).
[73] *See id.*
[74] Office of Enforcement and Compliance, et al., *§309 Reviewers Guidance for New Nuclear Power Plant Environmental Impact Statements*, U.S. ENV'T PROT. AGENCY at 10 (Sept. 2008).
[75] Postconstruction Environmental Reports, 10 C.F.R. § 51.53(c)(1)-(2) (2014).
[76] *Id.* at (c)(3)(ii)(L).
[77] Hearings and Judicial Review, 42 U.S.C. § 2239(a)(1)(A).
[78] *See generally* NRDC v. U.S. NRC, 823 F.3d 641 (D.C. Cir. 2016).

At first glance, the primary concern for the power plants is that they could rack up massive costs in defending their re-licensure request. Additionally, depending on when applicants apply for re-licensure, and how long the challenges carry out, it is entirely possible that the license expires before the disputes are settled. With that comes more harm to the environment because the clean energy produced by the power plant is removed from the grid and, as later detailed,[79] reliance on fossil fuels will increase as the consequence.

C. MANAGING NUCLEAR WASTE

A third concern surrounding nuclear power is that although nuclear power generation does not produce carbon dioxide emissions, there are harmful radioactive byproducts. Luckily, there are no technological problems with nuclear waste disposal. Most waste from nuclear power plants have relatively low-levels of radioactivity.[80] These wastes, such as uranium mill tailings and spent reactor fuel, are subject to special regulations that govern their disposal.[81] Uranium mill tailings and other low-level radioactive wastes make up about 90% of all nuclear waste.[82] The accepted disposal process involves burying waste at special sites, and covering it with clay, rocks, and soil.[83] This method helps to prevent harmful radiation from entering the atmosphere or impacting the people living around the dump sites. Intermediate and high-level radioactive wastes require further measures to ensure environmental safety. To allow for radioactive decay, spent reactor fuel is stored in water or dry casks for at least five years.[84] The waste can either remain in the dry casks or be stored in deep-Earth sites. In much of the world, deep-Earth sites are underdeveloped options. Finland has led the deep-Earth model of disposal. Intermediate and high-level nuclear waste would be sealed in copper caskets, buried 1,400 feet down in man-made caverns, surrounded

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[79] *Infra* sec. III (A).

[80] *Nuclear explained: Nuclear power and the environment*, U.S. ENERGY INFO. ADMIN. (Jan. 15, 2020), *available at* https://www.eia.gov/energyexplained/nuclear/nuclear-power-and-the-environment.php (last visited Oct. 6, 2022).

[81] *Id.*

[82] *Storage and Disposal of Radioactive Waste*, WORLD NUCLEAR ASS'N (May, 2021), *available at* https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste.aspx (last visited Jan. 16, 2023).

[83] U.S. ENERGY INFO. ADMIN., *supra* note 80.

[84] *Id.*

by granite and packed with clay.[85] Experts have reviewed the Finnish plan, and it is believed to be sufficient to prevent leaks to the Earth's surface or into water tables.[86]

A plan like this is feasible anywhere in the world. Canada, Russia, China, and France are exploring deep-Earth waste repositories and seem to trust that this option is the best nuclear waste management practice currently available.[87] In the U.S., deep-Earth options have been discussed by multiple presidents but none have felt the need to pursue it.[88] Environmental reviews would likely be necessary for countries to move forward with these plans. For example, under a NEPA review in the U.S.,[89] the political hesitancies should be put to rest, so long as the same environmental findings from around the world are reflected in U.S. environmental studies. Expectedly, most people accept that waste produced by nuclear power plants within their country should be disposed of in their country.[90] Although multi-national nuclear waste repositories are an idea of the past,[91] storing nuclear energy in these national deep-Earth sites still carries global implications if mismanaged. It is important for countries to pick deep-Earth repository locations that are not likely subject to earthquakes or human development and interference, to ensure that the chance of a radioactive leak into the air, ground water, or soil, is next to zero.

Nuclear waste around the world is not unmanageable either. The total amount of intermediate and highly radioactive nuclear waste

[85] Henry Fountain, *On Nuclear Waste, Finland Shows U.S. How It Can Be Done*, THE N.Y. TIMES (Jun.e 9, 2017), *available at* https://www.nytimes.com/2017/06/09/science/nuclear-reactor-waste-finland.html (last visited Jan. 16, 2023).

[86] *Id.*

[87] *What Other Countries Are Doing*, NUCLEAR WASTE MGMT. ORG., *available at* https://www.nwmo.ca/en/Canadas-Plan/What-Other-Countries-Are-Doing (last visited Jan. 16, 2023).

[88] *What is the Yucca Mountain Repository?* U.S. ENV'T PROT. AGENCY, *available at* https://www.epa.gov/radiation/what-yucca-mountain-repository (last visited Jan. 16, 2023).

[89] *What is the National Environmental Policy Act?* U.N. ENV'T PROGRAMME, *available at* https://www.epa.gov/nepa/what-national-environmental-policy-act (last visited Jan. 16, 2023) (NEPA requires "all federal agencies...to prepare detailed statements assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment.").

[90] Kerri Morrison, *National and Multinational Strategies for Radioactive Waste Disposal*, 47 UNI. OF MD. ENV. L. PROGRAM 10300, 10309 (2017).

[91] *See id.*

produced in U.S. history currently hovers around 90,000 tons,[92] and would fill only one football field about thirty feet deep.[93] The same can be said for other countries, as well. In 2020, there was about a quarter million tons of intermediate and highly radioactive waste around the world,[94] which is just two more football fields, thirty feet down. Since disposal of nuclear waste is not unfeasible from a technological standpoint, it becomes clear that the problem lies with governments that refuse to further nuclear waste disposal research. They would rather the waste sit in vats down the street from grandma and grandpa's house. This perpetuates the idea that nuclear waste is dangerous and not worthy of continued investment, which ultimately increases operating costs, and the cycle perpetuates. In association with their respective environmental reviews, the international community should adopt the Finnish deep-Earth model in order to sustainably remove highly radioactive wastes from Earth's surface, and to help heal its reputation while working toward a carbon-free future.

D. PUBLIC PERCEPTION OF NUCLEAR MELTDOWNS AND WEAPONS

A fourth concern surrounding nuclear power is public fear. Much of the global concern associated with nuclear energy rests on what the world knows about a few nuclear power plant accidents, as well as the misplaced belief that nuclear power plants equate to nuclear weapons. It is of initial importance to briefly describe the complex science behind what constitutes a nuclear meltdown. Operating a nuclear reactor involves creating carefully controlled reactions where uranium atoms are split by neutrons, called nuclear fission.[95] As the atoms split, heat is produced, cold water within the reactor is heated, and resulting steam powers turbines within the reactor that ultimately generate electricity.[96]

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[92] Mitch Jacoby, *As nuclear waste piles up, scientists seek the best long-term storage solutions*, CHEMICAL & ENG'G NEWS (Mar. 30, 2020), *available at* https://cen.acs.org/environment/pollution/nuclear-waste-pilesscientists-seek-best/98/i12 (last visited Jan. 15, 2023).

[93] Hannah Hickman, *What Happens to Nuclear Waste in the U.S.*, NUCLEAR ENERGY INST. (Nov. 19, 2019), *available at* https://www.nei.org/news/2019/what-happens-nuclear-waste-us (last visited Jan. 15, 2023).

[94] Jacoby, *supra* note 92.

[95] Jenny Marder, *Mechanics of a Nuclear Meltdown Explained*, PBS (Mar. 15, 2011), *available at* https://www.pbs.org/newshour/science/mechanics-of-a-meltdown-explained (last visited Jan. 16, 2023).

[96] *Id.*

In a meltdown, this process runs uncontrolled due to mismanaged and excessive heating, which causes water to rapidly evaporate, increasing pressure with the reactor, and resulting in a "rupture" that releases radioactive vapors into the atmosphere.[97] Beyond the science, three nuclear meltdowns remain ever-present in people's mind: Chernobyl, Three Mile Island, and Fukushima Daiichi.

The Chernobyl nuclear power plant meltdown was not a product of nuclear fission or anything inherent to nuclear energy production; in fact, the cause was human idiocy.[98] Technologists working at the plant decided to run an experiment in complete violation of established safety procedures, all the while giving plant operators no warning in which they could attempt to mitigate or plan for the experiment.[99] The Three Mile Island meltdown was once again caused by negligent human error. This time, operators ignored emergency procedures, and shut off the cooling mechanism based on their own gross misreading of data.[100] Many people in the surrounding area claimed they were affected; however, the science does not support this. The NRC concluded that the average dose of radiation exposure to the approximately two-million people around the power plant was less than the radiation people are exposed to when they get an x-ray;[101] a harmless amount of radiation. The Fukushima Daiichi meltdown was caused by a mixture of human error and natural disaster. A tsunami crashed over the flood walls around the nuclear power plant, entering the reactors, and causing the cooling mechanisms to shut down.[102] As a result, the reactors over-heated and exploded.[103] An inspection report conducted by the International Atomic Energy Agency [hereinafter IAEA] determined that the Japanese government failed to prepare adequate backup systems in emergency situations,[104] which, unfortunately, was on display after the tsunami.

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[97] GALEN J. SUPPES & TRUMAN S. STORVICK, SUSTAINABLE NUCLEAR POWER, 341 (Academic Press, 1st ed. 2006).
[98] *Id.*
[99] *Id.* at 342.
[100] *Id.* at 343.
[101] *Three Mile Island Accident*, NUCLEAR REGUL. COMM'N (Mar. 2004), *available at* https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html (last visited Jan. 16, 2023).
[102] Martin Fackler, *Report Finds Japan Underestimated Tsunami Danger*, THE N.Y. TIMES (June 1, 2011), *available at* https://www.nytimes.com/2011/06/02/world/asia/02japan.html (last visited Jan. 16, 2023).
[103] *Id.*
[104] DIRECTOR GENERAL, THE FUKUSHIMA DAICHI ACCIDENT at 3-7 (Int'l Atomic Energy Agency eds.) (2015).

Each of these instances have led to safety, regulatory, procedural, and technological reform in operating nuclear power plants.[105] It is notable that despite the perception of danger in nuclear power plants, per each 1000TWh of energy generated, they remain the least deadly energy source. Solar and wind technologies result in 440 and 150 deaths/1000TWh of energy generated, respectively,[106] primarily from construction and installation accidents.[107] Hydroelectric power production results in about 1500 deaths/1000TWh of energy generated,[108] overwhelmingly due to dam breaks and flooding.[109] Fossil fuel technologies are an entirely scarier bear: Coal leads to 100,000 deaths/1000TWh of energy produced, oil leads to 36,000 deaths/1000TWh of energy produced, and gas leads to 4,000 deaths/1000TWh of energy produced.[110] Nuclear on the other hand leads to 90 deaths/1000TWh of energy produced.[111] The studies are clear and counter to public perception: Nuclear energy is the least dangerous. Period.

Another misconception is that nuclear power plants are similar to or encourage nuclear weapons. While the underlying science behind how nuclear power plants and nuclear weapons operate,[112] they operate in their respective lanes. Both are addressed in the Treaty on the Non-Proliferation of Nuclear Weapons [hereinafter NPT]. The NPT is an international treaty with the objective to stop the spread of nuclear weapons technology to countries without the ability to build nuclear weapons, while also encouraging the peaceful use of nuclear energy.[113] At the time they each joined the NPT, Russia [formerly as the Soviet

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[105] *Id.*

[106] Madhumitha Jaganmohan, *Global Mortality Rate by Energy Source 2012*, STATISTA (Jan. 29, 2021), *available at* https://www.statista.com/statistics/494425/death-rate-worldwide-by-energy-source/ (last visited Jan. 16, 2023).

[107] James Conca, *How Deadly is Your Kilowatt? We Rank Your Killer Energy Sources*, FORBES (June 10, 2012), available at https://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/?sh=454ba191709b (last visited Oct. 2, 2022).

[108] Jaganmohan, *supra* note 106.

[109] Conca, *supra* note 107.

[110] Jaganmohan, *supra* note 106.

[111] *Id.*

[112] Lars Sorge & Anne Neumann, *Warheads of Energy: Exploring the linkages between civilian nuclear power and nuclear weapons in seven countries*, 81 ENERGY RESEARCH & SOCIAL SCIENCE, Nov. 2021, at 14.

[113] Treaty On the Non-Proliferation of Nuclear Weapons, Jul. 1, 1968, 729 U.N.T.S. 161.

Union], the United States, France, the United Kingdom, and China all had nuclear weapons, effectively grandfathered in, and allowed to possess nuclear weapons.[114] The remaining parties all pledge to honor the IAEA's guidelines that requires countries possessing nuclear energy technologies to demonstrate that they are not diverting efforts or technologies to develop nuclear weapons.[115] At this juncture, thirty-two of the thirty-four countries with or planning nuclear power plants, have not developed nuclear weapons after joining the NPT.[116] The two countries that have nuclear weapons and nuclear power plants are, in fact, not even members of the NPT.[117] Additionally, the two other non-NPT parties that have nuclear weapons do not have nuclear power plants within their borders.[118] What can be ascertained from this information is that nuclear power plants do not equate to nuclear weapons. They operate in their own lanes, regulated on different grounds, and for the most part, it does not appear to be a pre-requisite that when a country has nuclear power plants, they develop nuclear weapons.

With all of this in mind, is the fear of nuclear power really warranted?

E. SMR'S INFANCY

A fifth concern surrounding nuclear power is that although SMRs are a burgeoning technology with great potential, some people doubt how effective SMRs can be in combatting climate change. Their concerns stem from issues of cost and time. First, manufacturing SMRs is not a solidified process. There are still significant kinks to work out. For example, finding the lowest cost cooling process for the reactors,[119] and ensuring that SMRs retain the same capacity factor as normal nuclear power plants.[120] Additionally, SMRs have to be created outside of mass

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[114] *Id.* at art. I.

[115] *Id.* at art. III.

[116] NUCLEAR POWER REACTORS IN THE WORLD, INT'L ATOMIC ENERGY AGENCY (2020).

[117] Id.; supra note 113 (those two countries are India and Pakistan).

[118] *Supra* note 113*; supra note 116; (those two countries are North Korea and Israel).*

[119] Arjun Makhijani & M.V. Ramana, *Why Small Modular Nuclear Reactors Won't Help Counter the Climate Crisis*, EWG (Mar. 25, 2021), available at https://www.ewg.org/news-insights/news/why-small-modular-nuclear-reactors-wont-help-counter-climate-crisis (last visited Jan. 15, 2022).

[120] M.V. Ramana, *Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Nuclear Reactors,*

manufacturing, to establish the legitimacy of the technology, in order to stimulate investment to create the supply chain to warrant mass manufacturing and further investment.[121] Second, the SMR contribution to reducing carbon emissions over the next decade will be very minimal. As of 2021, projected deployment dates for SMRs are 2029,[122] which is the year before the first climate target set in the Paris Agreement. If they are barely deployed, how can they help meet climate concerns today?

While these concerns are legitimate, they are a bit too pessimistic. All of the issues with renewables will not be solved today either; they too, will take years to resolve. Further, the ability to deploy SMRs to remote areas is a long-term goal, on top of the climate crisis. Since SMRs take up very little space, and are readily connectable to power grids, they are better options for those areas than renewables. If investments in SMRs are cut because their issues will not be resolved yesterday, then investment in renewables should be cut, too—but that would never happen, and it should not happen. It will take decades to fully move away from fossil fuels, so why is investing in SMRs a waste of time but investing in renewables is not? Additionally, SMRs are not going to be the only solution to climate change; other strategies are necessary to lower emissions across all industries, not just the energy industry. Coupled with many other carbon reducing technologies, SMRs still can be deployed for well over half of the twenty-first century, which is the aspiring deadline for international climate objectives.

III. Renewable Energy Is Not Ready Yet

It is clear from the UNEP's *United in Science 2021*[123] and *Emissions Gap 2021*[124] reports, along with the National Intelligence Council's 2040 projections report,[125] that not only are climate change mitigation plans not aggressive enough to meet the objectives of the Paris Agreement or the commitments made at COP26, but that detrimental effects to the environment and all living species are inevitable under current plans. In order to prevent the negative consequences facing the planet, governments need to embrace logical efforts, however mistakenly controversial, for the planet's long-term benefits. To meet international

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OR. PHYSICIANS FOR SOC. RESP. at 15 (Sept. 2020), *available at* https://www.oregonpsr.org/report-uamps-nuscale-smrs (last visited Jan.15, 2022).

[121] Makhijani & Ramana, *supra* note 119.

[122] Ramana, *supra* note 120, at 8.

[123] *See discussion supra* I(B), at ¶ 2.

[124] *See discussion supra* I(B), at ¶ 4.

[125] *See discussion supra* I(B), at ¶ 3.

climate change goals, seeking aggressive decarbonization policies to create a carbon-free energy sector are vital, and should have begun yesterday. In pursuit of meeting these goals, many policymakers and environmentalists believe that renewable energies are ready to bear the load.[126] This fallacy poses significant harm in the short and long-term, and will lead to a regression of global climate change progress. In pursuit of global climate mitigation goals and a clean energy sector, the insufficiencies of the renewable energy sector must be addressed to avoid unintended consequences of misinformed policy.

A. CURRENT RENEWABLE TECHNOLOGIES CANNOT MEET RISING DEMANDS

As renewable energy technologies continue to mature, they must be able to meet energy demands. The International Energy Agency's Electricity Report says that the demand for electricity will continue to rise for the foreseeable future,[127] understandably so as the global population continues to rise. Electricity generation from renewable sources will also continue to rise, but it cannot keep up with the increasing demand.[128] Even though renewables grew by an average of 8% over the last couple of years, global electricity demand continues to grow more, and as a result, electricity generation via coal and gas hit record highs.[129] Essentially, the expansion and implementation of renewable energies is not happening fast enough to counter the growth in energy demand. What this indicates is that even though renewables are growing like never before, with the decommissioning of nuclear power plants and growing populations, fossil fuel reliance will rise in the immediate future, and so will greenhouse gas emissions. There is no reason to move away from nuclear energy, a clean energy source, when the absence of it will increase fossil fuel reliance, and erase climate change mitigation progress.

International Energy Agency Director of Energy Markets and Security, Keisuke Sadamori, bluntly stated that renewable power is not

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[126] The Sky's the Limit: Solar and Wind Energy Potential is 100 Times as Much as Global Energy Demand, CARBON TRACKER INITIATIVE (Apr. 23, 2021), available at https://carbontracker.org/reports/the-skys-the-limit-solar-wind/ (last visited Jan 15, 2023).

[127] Electricity Market Report, INT'L ENERGY AGENCY (Jan. 2022), *available at* https://www.iea.org/reports/electricity-market-report-january-2022 (last visited Oct. 3, 2022).

[128] *Id.*

[129] *Id.*

"where it needs to be to put [the world] on a path to reaching net-zero emissions by mid-century."[130] Sadamori went on to say that "to shift to a sustainable trajectory, [countries] need to massively [increase] investment in clean energy technologies."[131] Certainly, this means increasing funding and efforts for developing renewable energy technologies, but his advice also leaves open the door to other clean energy options—such as nuclear energy. Renewable energies are the future of energy generation but the technologies are simply not developed enough to take over right now. If nuclear energy is removed from the equation while renewables are not ready to bear the load, that only invites increased reliance on fossil fuels to fill the gap left by the absence of nuclear energy. Continued nuclear energy investments in existing technologies will allow renewables the time to develop, without backtracking on climate progress in the process.

B. ENERGY GRIDS ARE NOT READY YET

Not only is the renewable energy sector not growing fast enough to substantially and rapidly reduce reliance on fossil fuels, energy grids are not equipped for a quick transition either. Energy grids need to be modified to integrate larger amounts of wind and solar energy.[132] Wind and solar are energy types with low load factors, which means that their inputs are inconsistent[133] and not always available when needed.[134] This lack of reliability stems from the nature of relying on the weather to generate energy. When renewable sources are the primary energy input onto power grids, the grids must be flexible to account for less reliable energy inputs, to balance supply and demand, and to integrate energy storage capabilities for such intermittent inputs.[135]

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[130] Anmar Frangoul, *Renewable electricity generation is growing – but it's not enough to meet rising demand, IEA says*, CNBC (July 15, 2021), *available at* https://www.cnbc.com/2021/07/15/renewable-generation-growing-but-not-enough-to-meet-demand-iea-says.html (last visited Jan. 20, 2023) (the International Energy Agency collaborates with countries to shape energy policies to reach a sustainable future).

[131] *Id.*

[132] Susan Tierney & Lori Bird, *Setting the Record Straight About Renewable Energy*, WORLD RES. INST. (May 12, 2020), *available at* https://www.wri.org/insights/setting-record-straight-about-renewable-energy (last visited Oct. 3, 2022).

[133] *Supra* note 13, at 67.

[134] *Supra* note 13, at 72.

[135] *Supra* note 13, at 72-73.

Unlike renewable energy sources, nuclear energy is an inherently flexible energy source.[136] Not only is nuclear energy input already flexible on power grids, but the output from nuclear power plants can be modified to meet the demands on certain power grids.[137] With or without nuclear energy in the mix, renewable energy input requires flexibility on power grids that is not available yet. In order to counter the intermittent supply of renewables, there would need to be large-scale energy storage units that can house energy for times when wind or solar inputs are producing less efficiently. An option to handle the flexibility issue is battery storage.[138] However, battery technologies necessary to support power grids are still in their infancy. Current batteries do not have large enough storage capabilities to accommodate power grids that rely primarily on renewable energy input.[139] Much like the renewable energy technologies, energy storage technologies are not ready to replace the amount of fossil fuel generated energy that currently supplies energy grids. By continuing to invest in nuclear energy, time is given to the battery storage technologies to advance in order to fit power grids that are primarily supplied by renewable sources. Until there is a uniform and advanced mechanism for managing intermittent energy inputs onto grids, renewables are not ready to take over the role as the primary energy supplier to power grids.

C. INHERENT FLAWS IN RENEWABLE ENERGY PRODUCTION

Renewables are less reliable energy sources because when the sun does not shine, when the wind does not blow, and when the water does not flow, energy is not produced.[140] Nuclear power plants, on the other hand, do not have this problem, and operate at significantly higher productivity levels, also called the capacity factor. The capacity factor of a power source is the measure of the average percent of time that energy

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[136] 3 Ways Nuclear Is More Flexible Than You Think, OFF. OF NUCLEAR ENERGY (June 23, 2020), available at https://www.energy.gov/ne/articles/3-ways-nuclear-more-flexible-you-might-think (last visited Jan. 20, 2023).
[137] *Id.* (modification involves ramping up or decreasing reaction speeds within nuclear reactors).
[138] *Supra* note 13, at 75.
[139] *Id.*
[140] *See* Christopher McFadden, *Is 100% Renewable Energy Enough For The World?*, INTERESTING ENGINEERING (Dec. 12, 2018), *available at* https://interestingengineering.com/is-100-renewable-energy-enough-for-the-world (last visited Jan. 15, 2023).

is produced.[141] On average, renewables have relatively low capacity factors. Solar panels produce energy ninety-two days of the year, thus having a capacity factor of 25.1%.[142] For wind and hydro power, these numbers are slightly higher at 127 days (34.5%) and 138 days per year (38.2%), respectively.[143] Nuclear power plants have a capacity factor of 336 days, or 92.3%.[144]

The amount of energy produced by these different sources are not equivalent per power plant, factory, or solar or wind farm. For example, a typical nuclear reactor generates around one gigawatt (GW) of electricity.[145] Given the differing capacity factors, in order to replace one nuclear power plant, there would need to be about three or four one-GW solar or wind farms to replace to productivity of the single nuclear power plant.[146] This number translates to over three million solar panels, and over 400 large utility-scale wind turbines.[147] The land required for replacing nuclear power plants is immense. To shut down the nearly ninety remaining nuclear power plants in the U.S. would require, for example, at least around 300 million solar panels. But an easier solution remains. Nuclear power is highly efficient and highly reliable. Nuclear energy generation does not rely on uncontrollable factors, like the weather. Further, nuclear energy is flexible, and can produce higher quantities of energy without requiring more land to do so, since energy production occurs within the nuclear reactors at the power plants.

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[141] Richard Rhodes, *Why Nuclear Power Must Be Part of the Energy Solution*, YALE SCH. OF THE ENV'T (July 19, 2018), *available at* https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate (last visited Jan. 15, 2023).

[142] *Id.*

[143] *Id.*

[144] *Id.* [the non-operating days occurred because of general maintenance to the power plants, not because of flaws in the energy production process].

[145] *Nuclear Power is the Most Reliable Energy Source and It's Not Even Close*, OFF. OF NUCLEAR ENERGY (Mar. 24, 2021), *available at* https://www.energy.gov/ne/articles/nuclear-power-most-reliable-energy-source-and-its-not-even-close (last visited Jan. 18, 2023).

[146] *Id.*

[147] *How Much Power Does A Nuclear Reactor Produce?*, Off. of Nuclear Energy (Mar. 31, 2021), *available at* https://www.energy.gov/ne/articles/infographic-how-much-power-does-nuclear-reactor-*produce* (last visited Oct. 24, 2022).

D. LAND ISSUES IN ACCOMMODATING RENEWABLE ENERGY GROWTH

Space concerns continue to trouble the renewable energy sector. Large amounts of land are necessary when constructing solar or wind farms. Two studies offer realities on this issue. First, it has been estimated that if all of the roofs in the U.K. had solar panels, the energy produced would only provide for five percent of the country's needs.[148] Second, it has been calculated that in order to have a 100% renewable world, there would need to be 3.8 million large wind turbines, 90,000 utility-sized solar farms, 490,000 tidal turbines, 5,350 geo-thermal installations, and 900 hydro-electric plants.[149] Those estimations do not even account for a rising global population, or land scarcity caused by growing populations and land destruction resulting from fires, floods, or droughts. With less viable land, the quantity of usable space becomes scarcer.

Additionally, moving energy requires large power cable networks, significant amounts of land, and extensive construction that would take years. Currently, there are 34 million kilometers of power lines to transfer solar and wind energy that is produced in one location to another to accommodate regional weather differences and regions with varied amounts of daylight.[150] Expanding solar and wind energy will require an increase in power lines to about 50 million kilometers by 2040.[151] Where to put solar and wind fields is a major hurdle to renewable energy expansion. Combined with the space required for nearly doubling the power cable network, there is a significant land challenge that is difficult to rectify in the short time necessary for an effective renewable energy take-over by mid-century in order to meet international climate goals.

To meet international climate goals on its own, renewable energy would need to grow three times faster than it is currently,[152] while overcoming serious issues related to land scarcity, technological lapses, and inherent energy production handicaps. It would be unwise to continue rapidly closing nuclear power plants when there remains so much to configure on the renewable energy front. Renewables are not capable of bearing the load that is an ever-rising energy demand. Extending nuclear energy investments offers a crutch for the pitfalls of

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[148] McFadden, *supra* note 140.
[149] *Id.*
[150] McFadden, *supra* note 140.
[151] McFadden, *supra* note 140.
[152] *Nuclear Power in a Clean Energy System*, *supra* note 13.

renewables as the international community looks toward a carbon-free future in the energy sector.

IV. Environmental Benefits of Extending Nuclear Energy Investments

Since the birth of nuclear power into the energy market, large amounts of CO_2 have been withheld from polluting the atmosphere. As a clean energy source, nuclear also holds the line of additional CO_2 emissions that would otherwise result from fossil fuel use in the absence of nuclear energy. If countries continue to decommission nuclear power plants before renewable energy sources are ready to bear the burden, existing environmental gains will be erased. Further, maintaining investments in nuclear energy will help the international community to close the emissions gap and make real progress in climate change mitigation.

A. DIVESTMENT ERASES EXISTING ENVIRONMENTAL GAINS

In order to ensure that international climate objectives are met, further investment in nuclear energy will be critical. Over the last fifty years, countries' use of nuclear power has avoided sixty-three gigatons of CO_2 emissions from entering the atmosphere.[153] If nuclear power was not part of the energy mix during this period, it is estimated that CO_2 emissions from the electricity generation industry would have been about 20% higher.[154] These savings were most substantial in the U.S., European Union, and in developing economies, but is consistent across the globe where the total amount of emissions avoided continues to rise.[155] The upward trend persists even with the boom of renewable energies. This is important because the decarbonization efficiency of nuclear energy is unaffected by diminished investment, and thus there remains value in what the use of nuclear energy can continue to keep out of the atmosphere. Until fossil fuels are almost entirely removed from the energy equation, CO_2 emissions will remain a problem if nuclear energy disappears.

Greenhouse gas emissions are measured in emissions of CO_2-equivalents per kilowatt hour of electricity through the life of the energy

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[153] *Nuclear in a Clean Energy System*, *supra* note 13 at 9.

[154] *Id.*

[155] *Id.*

source [hereinafter gCO_2eq/kWh].[156] This measurement takes into account the mining, construction, operation, and waste management phases of an energy source.[157] When broken down by energy type, nuclear has one of the lowest lifecycle emissions, which means it is one of the cleanest energy sources from extraction to burial. On average, coal, natural gas, and oil have lifecycle emissions of 820, 490,[158] and 720[159] gCO_2eq/kWh of electricity produced, respectively. Nuclear energy, on the other hand, has an average lifecycle emission of twelve gCO_2eq/kWh of electricity produced, as compared to solar (about forty-five gCO_2eq/kWh) and wind (about eleven gCO_2eq/kWh).[160] For reference, when comparing nuclear and coal at the same productivity level, coal produced sixty-eight times the emissions than nuclear. If solar and wind technologies are not yet ready to bear the burden as the primary energy source, it is problematic for countries to decommission one of the cleanest energy sources that is more productive than renewables and far cleaner than similarly efficient fossil fuels. From 1971-2018, if nuclear power was not a component in the energy system, "emissions from electricity generation would have been 25% higher in Japan, 45% higher in [South] Korea and over 50% higher in Canada."[161] It is odd to give up on nuclear energy at this juncture. This fact becomes more puzzling considering that closing nuclear power plants is proven to have immediate detrimental environmental consequences.

When nuclear power plants close, progress in decarbonizing the environment reverses. In the U.S., after every nuclear power plant closure, carbon emissions have increased.[162] For example, in 2013 the San Onofre Nuclear Generating Station in California closed, which had produced 8% of California's electricity.[163] Following the closure,

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[156] Thomas Bruckner, Et Al., *Annex III: Technology-specific Cost and Performance Parameters*, *in* CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 1329, 1335 (2015).
[157] *See id.*
[158] *Id.*
[159] Max Roser, *Why did renewables become so cheap so fast?*, OUR WORLD IN DATA (Dec. 1, 2020), *available at* https://ourworldindata.org/cheap-renewables-growth (last visited Jan. 16, 2023)
[160] Bruckner, *supra* note 156.
[161] *Supra* note 13.
[162] *Second License Renewal*, NUCLEAR ENERGY INST., *available at* https://www.nei.org/advocacy/preserve-nuclear-plants/second-license-renewal (last visited Jan. 24, 2023).
[163] Lois Parshley, *The controversial future of nuclear power in the U.S.*, NAT'L GEOGRAPHIC (May 4, 2021), *available at*

scientists observed not only an increase in the cost of electricity, but also an increase in CO_2 emissions by 9.2 million tons the following year.[164] In another instance, when the Vermont Yankee nuclear power plant closed in 2014, it raised electricity rates in Vermont, increased the state's carbon footprint, and required more natural gas importation to replace the hole left in the absence of nuclear energy.[165] Worsening carbon emissions following a nuclear power plant closure points back to the fact that renewables are not ready to meet the energy demand when nuclear power is gone. Vermont did not look toward increasing solar or wind fields in preparation to close the nuclear plant—they simply reversed course on environmental progress and defaulted to a dirty, high carbon-emitting energy source. And for what reason? Who wins in this scenario? Certainly not the environment, but perhaps the government trying to "save" money.

In the U.S., on average, nuclear power plants need a penny/kWh as a subsidy, while wind and solar get twice that.[166] Further, countries around the world simply have not given equitable support to the nuclear energy industry as they do other energy types, and generally continue to throw substantial amounts of money behind fossil fuels.[167] An example of positive nuclear investment can be found in New Jersey. The State enacted a nuclear energy subsidy program to assist nuclear power plants competing in the energy market.[168] In order for a plant to be eligible for a subsidy, a handful of requirements must be met. One of the requirements is that there must be evidence that the existing plant "makes a significant and material contribution to the air quality in the State by minimizing emissions that result from electricity" consumption across the State.[169] A second requirement is that there must be evidence that in

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https://www.nationalgeographic.com/environment/article/nuclear-plants-are-closing-in-the-us-should-we-build-more (last visited Jan. 24, 2023).

[164] *Id.*

[165] James Conca, *Communities Surrounding Closed Nuclear Power Plants Face Terrible Challenges Moving Forward,* FORBES (Oct. 25, 2020), *available at* https://www.forbes.com/sites/jamesconca/2020/10/25/communities-surrounding-closed-nuclear-power-plants-face-terrible-challenges-moving-forward/?sh=5e9a4d8f6278 (last visited Jan. 24, 2023).

[166] *Id.*

[167] *Energy Subsidies*, WORLD NUCLEAR ASS'N (Feb. 2018), *available at* https://world-nuclear.org/information-library/economic-aspects/energy-subsidies.aspx (last visited Jan. 24, 2023).

[168] Matter of Implementation of L. 2018, C. 16 Regarding the Establishment of Zero Emission Certificate Program for Eligible Nuclear Power Plants, 250 A.3d 1136, 1141 (N.J. Super. Ct. App. Div. 2021).

[169] *Id.*

absence of the nuclear power plant, there would be a significant and negative impact on State emission reduction efforts.[170] Amongst other non-environmental requirements, the nuclear power plants at issue in *Matter of Implementation of L. 2018* were subsidized further after positive environmental reports.[171]

New Jersey upheld the subsidizations in recognition of the importance nuclear energy has to a clean energy future, and how losing a significant clean energy source would cause destruction to the environment.

Without as much government support, it is obvious that the nuclear energy industry would face some issues, like lack of funding for long-term waste management. Continued divestment in the most productive, clean energy source is strange. When, such as in the case of the Vermont plant, fossil fuels are brought in to replace nuclear energy, there remains doubts that governments are even trying to save the environment anymore. It is highly unlikely that renewables alone are ready to carry the torch to a clean energy future.[172] Since renewables are unprepared, policymakers must consider what they care more about: Making real efforts to meet climate commitments, or making decisions that, frankly, are going to harm future generations.

B. FURTHER INVESTMENT WILL HELP CLOSE THE EMISSIONS GAP

With the emissions gap at its recorded worst, the disparity is enough to cause at least a 2.7°C warming above pre-industrial levels by the end of this century.[173] This prediction is not only a failure of international climate goals, but also poses reason to be afraid for the health of the planet. It would be great for an immediate renewable energy transition today because that would cut the emissions gap nearly overnight. Since that is not possible, utilizing nuclear power and increasing its use in the clean energy transition will help to do the same. Given what is known about the difficulties of full renewable reliance now, nuclear power appears to be the only reliable, low-carbon source of energy that should

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[170] *Id.*

[171] *See id.*

[172] *See, supra* Sec. III.

[173] Ajit Niranjan, *COP26: How to close the emissions gap and keep global warming to 1.5C,* DEUTSCHE WELLE (Nov. 1, 2021), *available at* https://www.dw.com/en/cop26-paris-agreement-solutions-climate/a-59681099 (last visited Jan. 24, 2023).

play a role in the energy future. This makes sense. Nuclear energy is clean, has a high capacity factor, occupies a relatively small spatial footprint, and is adjustable to meet fluctuating energy demands without needing to add storage capacities to existing power grids. All critical to closing the emissions gap.

Since about one gigaton of CO_2 emissions prevented from entering the atmosphere each year, this equates to removing the same amount of CO_2 emissions as taking 100 million passenger vehicles off the world's roads.[174] Removing or preventing one $GtCO_2e$ from the atmosphere will not save the planet itself, but governments will be hard pressed to find a policy change that does as much for decarbonization efforts as increasing nuclear dependency would do. In the 2021 Emissions Gap Report, various scenarios estimate by 2030 what amount of greenhouse gas emission ($GtCO_2e$) reductions are required to meet certain climate targets. It is projected that by 2030, current policies would only reduce greenhouse gas emissions to 55 $GtCO_2e$.[175] This estimate is still almost double the amount needed to meet the Paris Agreement objectives. In order to ensure the 2030 Paris Agreement benchmarks are met, scientists estimate a minimum carbon emissions reduction of 13 $GtCO_2e$ below current levels to achieve the 2°C goal, and a minimum carbon emissions reduction of 28 $GtCO_2e$ below current levels to achieve the 1.5°C goal.[176] In the context of nuclear energy investment and closing the emissions gap, this calls for two actions. First, as discussed in the next section, further investment in nuclear energy by countries that already rely on nuclear energy.[177] Second, encouraging expansive nuclear use in developing nations, such as China and India.

There is great potential for further nuclear energy use to keep massive amounts of CO_2 from the atmosphere. For about the last ten years, China and India have had the fastest growing contributions to global pollution.[178] This accompanies their rapidly growing populations, which will inevitably cause a continued increase in energy demands. Demands that will outpace the growth of renewables.[179] In 2019, China

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[174] *Advantages: Climate*, NUCLEAR ENERGY INST., *available at* https://www.nei.org/advantages/climate (last visited Jan. 24, 2023).
[175] *Emissions Gap Report 2021*, *supra* note 56, at 34.

[176] *Id.* at 35.
[177] *Infra* Sec. V.
[178] *Report: China emissions exceed all developed nations combined*, BBC NEWS (May 7, 2021), *available at* https://www.bbc.com/news/world-asia-57018837 (last visited Jan. 24, 2023).
[179] *Supra* Sec. III(A).

contributed to 27% of global greenhouse gas emissions, while India contributed 7%.[180] At the same time, they both are rapidly expanding their nuclear energy usage. Of the fifty-two nuclear power plants currently under construction, fourteen are in China, and six are in India.[181] In addition to those plants, China and India show no signs of slowing down with dozens more planned.[182] As of 2020, nuclear generated about 5% of China's electricity, and about 3% in India.[183] Unlike most countries in the world, China and India are excited to invest and to expand on nuclear energy use. Their governments do not have massive decommissioning plans, and they believe that nuclear energy is part of their clean energy futures.[184] Since China and India are large greenhouse gas emitters, further investments in nuclear energy are highly beneficial to global climate objectives. It is estimated that if each coal-fired power plant brought online in China in 2018 was replaced by a nuclear power plant instead, China would have avoided 0.32 $GtCO_2e$.[185] Considering the emissions needed to be withheld from the atmosphere by 2030,[186] China's nuclear expansion alone would bring enormous benefits over the next eight years, and could account for nearly 20% of the progress needed to correct and maintain pace with the objectives of the Paris Agreement.

The World Energy Council conducted projections on how to achieve a sustainable energy transition as the world moves away from fossil fuels. In every single projection, the energy mix scenario includes nuclear

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[180] *Id.*

[181] Under Construction Reactors, *Power Reactor Information System,* INT'L ATOMIC ENERGY AGENCY, *available at* https://pris.iaea.org/PRIS/WorldStatistics/UnderConstructionReactorsByCountry.aspx (last visited Jan. 24, 2023).

[182] Florian Zandt, *Asia's Going Nuclear*, STATISTA (Dec. 21, 2021), *available at* https://www.statista.com/chart/26439/number-of-nuclear-reactors-currently-in-construction-or-in-preliminary-construction-stages/ (last visited Jan. 24, 2023).

[183] Ritchie & Roser, *supra* note 14.

[184] Murtaugh & Chia, *supra* note 23; *see also* Vishwa Mohan, *India to increase nuclear energy capacity three times in next 10 years to reduce its carbon footprints*, THE TIME OF INDIA (Sept. 15, 2021), *available at* https://timesofindia.indiatimes.com/india/india-to-increase-nuclear-energy-capacity-three-times-in-next-10-years-to-reduce-its-carbon-footprints/articleshow/86222428.cms (last visited Jan. 24, 2023).

[185] *Guide to Chinese Climate Policy*, CTR. ON GLOB. ENERGY POL'Y,, COLUM. UNIV., available at https://chineseclimatepolicy.energypolicy.columbia.edu/en/nuclear-power (last visited Jan. 24, 2023).

[186] *Supra* Sec. IV.B., at para. 2.

power.[187] In the most middle-ground scenario, the share of nuclear energy grows six-fold by 2050,[188] recognizing that in order to meet the decarbonization objectives and dates imposed by the international community, further nuclear power investment is not just encouraged, but required. The projections also indicate that the more ambitious the decarbonization and climate targets, the greater the role that nuclear energy must play.[189] With this information in mind, China and India's plans seem to match with these climate projections. To turn away from nuclear energy at a point when the world needs realistic climate policy to meet international goals, makes little logistical, technological, and scientific sense if achieving a carbon-free future is the goal.

V. How to Pursue Further Nuclear Investment

As many nuclear power plants across the world reach the end of their licensed lives, policymakers must decide how, or if, to replace nuclear energy. Additionally, given refined nuclear energy technologies, utilizing SMRs are an increasingly attractive option for expanding the nuclear energy sector in the short-term. With the dangers of fossil fuels, and the infancy-related flaws of renewable energies, the international community should not yet give up on nuclear energy. Nuclear power plants are the only high-capacity, reliable low-carbon energy source that has years of productivity left in them; yet plans to decommission them come at the expense of climate progress.

A. UTILIZING LICENSE EXTENSIONS

Nuclear power plants are licensed to operate for varying lengths of time, based on a country's policy. In the U.S., when a nuclear power plant is built, it is initially licensed by the federal government to operate for forty years.[190] In France, initial licenses are for ten years, and in Russia licenses are for thirty years.[191] Although these license terms are imposed, the licenses can be renewed. Given improved technologies and engineering assessments, many nuclear power plants, specifically the reactors, can operate beyond the initial license period.[192] The extension periods also vary from country to country. In the U.S., the extensions are

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[187] Nuclear Power in a Clean Energy System, *supra* note 34.
[188] *Id.*
[189] *See generally id.*
[190] *Second License Renewal, supra* note 162.
[191] *Under Construction Reactors, supra* note 181.
[192] *See id.*

for twenty years, while in France they are for ten years, and in Russia they are for fifteen or thirty years, depending on the age of the reactor.[193] In order to be eligible for a renewal, governments perform checks to determine the future of a plant. For example, in the U.S., in order for the government to grant a license extension, a power plant must pass safety and environmental reviews.[194] During these reviews, the power plant is checked against regulations for fire protection, environmental impact, and meltdown prevention mechanisms, all of which are established and monitored by the U.S. Nuclear Regulatory Commission.[195] All countries with nuclear power plants have similar agencies that check for safety to determine if a nuclear reactor should be granted a license extension, or if it should be decommissioned.[196] Safety dependent, the benefits of license extensions are primarily economic because building new, traditional nuclear reactors is a long and expensive project.[197]

Governments continue to renew licenses for nuclear power plants that have sought the extensions.[198] Many nuclear power plants in the U.S. have already received their first license renewal.[199] Over the next decade, those plants may seek additional license extensions for twenty more years,[200] unless the U.S. government continues decommission rates either before or at the time renewals are requested. Power plants are not given an expiration date, rather, the license expiration dates are meant for conducting reviews.[201] It is not a matter of the plants being too old to operate. Countries should take advantage of the operating lives of their power plants and seek to extend licenses, when safety and environmental checks are satisfied, rather than shutting down the plants. This is a move that could play a critical role in advancing decarbonization efforts to meet international climate goals. The U.S. government has closed eleven

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193 *Id.*

194 *Background on Reactor License Renewal*, U.S. NUCLEAR REGUL. COMM'N. (Jan. 2022), *available at* https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-reactor-license-renewal.html (last visited Jan. 16, 2023).

195 *Id.*

196 *See generally Nuclear Regulation & Regulators*, WORLD NUCLEAR ASS'N, *available at* https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/appendices/nuclear-regulation-regulators.aspx (last visited Jan. 16, 2023).

197 *See Construction and Commission of Nuclear Power Plants*, INT'L ATOMIC ENERGY AGENCY, *available at* https://www.iaea.org/topics/construction-and-commissioning-of-nuclear-power-plants (last visited Jan. 16, 2023).

198 *Under Construction Reactors, supra* note 181.

199 *Under Construction Reactors, supra* note 162.

200 *Id.*

201 *Id.*

nuclear power plants in the last five years, rationalized by high operating costs.[202] Other countries rationalize decommission efforts on similar grounds.[203] Governments are closing nuclear power plants without consideration of how to replace the lost energy. It is premature to remove nuclear power from the global energy sector without any plan to mitigate the productivity problem facing renewables, or without addressing the imminent carbon emissions increase to follow the inevitable reliance on fossil fuels in the absence of nuclear energy input.

B. INVESTING IN ADVANCED SMALL MODULAR REACTORS

Although standard nuclear power plant technologies have not developed much because of increased decommissioning efforts, smaller sized nuclear reactors have burst into the market. SMRs are nuclear reactors that have about one-third of the generating capacity of traditional nuclear reactors.[204] Although producing a third of the electricity that standard nuclear reactors can, SMRs still produce a large amount of low-carbon electricity.[205] The advantages of using SMRs are linked to their size and efficiency. First, SMRs can be factory made, and can be transported and installed as a ready-to-use unit.[206] This is an advantage over standard nuclear reactors because this process is cheaper, requires less labor,[207] and does not require lengthy on-site construction. Not only that, but SMRs cover a very small amount of land for the amount of energy that is produced, particularly when compared to the land needed for wind and solar farms.

Across the world, rural and isolated people's access to electricity is an ongoing equity issue. A second advantage of SMRs is that since they are transportable, governments can send them to isolated regions, install them into existing power grids, and use them to meet energy demands.[208]

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[202] *Nuclear Power in a Clean Energy System*, *supra* note 13, at 42.

[203] *Nuclear power: Downward trend ahead of climate summit*, *supra* note 10.

[204] Joanne Liou, *What are Small Modular Reactors (SMRs)?*, INT'L ATOMIC ENERGY AGENCY (Nov. 4, 2021), *available at* https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs (last visited Jan. 24, 2023).

[205] *Id.*

[206] *Id.*

[207] *Id.*

[208] *Small Modular Reactors*, NUCLEAR ENERGY INST., *available at* https://www.nei.org/advocacy/build-new-reactors/small-modular-reactors (last visited Jan. 24, 2023).

Again, the moveable nature of SMRs lends a hand to closing the gap in electricity inequity, providing clean and reliable power supplies to more people. A third advantage of SMRs is that they can serve as backup power supplies.[209] This becomes particularly helpful in looking toward transitioning to a majority renewable energy power system. Since renewables are intermittent energy supplies, and the technologically underdeveloped batteries are critical to supporting a predominantly renewable sourced power grid, SMRs can lend a further hand to fill the gaps that are produced by renewable energy's inherent flaws. A fourth advantage is that SMRs are safer than standard nuclear reactors. For example, SMRs rely on passive systems as well as low power and low operating pressures inside the reactors.[210] This means that human intervention to shut down a reactor is not required because natural circulation, convection, gravity, and self-pressurization are used as a self-safety check.[211] A fifth advantage is that factory production helps to avoid the slow and lengthy license application process, specifically as it relates to design issues because mass-industrial production would ideally have design kinks ironed out.[212] These factors increase safety and lowers the possibility of radioactive leaks and thus reduce the harm to the public and the environment.[213]

SMRs are tested and developed throughout Asia and the Americas.[214] Further investment in nuclear energy will be beneficial to mitigating climate change. Whether extending licenses on existing standard nuclear power plants, or ramping up investment and implementation of SMRs, either option will allow nuclear energy to operate flexibly and efficiently to continue meeting energy demands and preventing harmful pollutants from entering the atmosphere.

Conclusion

Whether the term "nuclear energy" invokes ideas of Homer Simpson, green goo, or fear of sprouting another limb, much of the internal biases surrounding nuclear energy are misplaced. The Paris Agreement sets forth critical benchmarks that the international community needs to meet in order to avoid widespread harm to air

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209 Liou, *supra* note 204.
210 *Id.*
211 *Id.*
212 Carl Stenberg, *Energy Transitions and the Future of Nuclear Energy: A Case for Small Modular Reactors*, 11 WASH. J. ENV'T L. & POL'Y 57, 81 (2020).
213 *Id.* at 84.
214 *Id.*

quality, oceans, animals, and humanity. Current policies are insufficient, and have already begun to lay the groundwork for embarrassing failure.

Fossil fuels plague every aspect of our planet, and rather than taking their hazards seriously, governments seem complacent and ready to allow fossil fuels to tighten their suffocating grip on the world. By decommissioning nuclear power plants in the face of renewable energy shortcomings, CO_2 levels will rise because of increased fossil fuel reliance. This reality bastardizes the sanctity of the Paris Agreement, all but ensuring the predicted harms of climate change come true: Prolonged heat waves, stronger storms, increased coastal flooding, and so on.

To prevent these results, the international community should maintain existing investment in nuclear power plants and seek to expand nuclear energy's long-term benefits by investing in new nuclear technologies, such as SMRs. Although there are an array of concerns surrounding nuclear energy, these concerns are misplaced; either due to incorrect public understanding, or government manipulation that can be solved with proper, environmentally focused policy-making. Renewable energy technologies are not ready to bear the burden of the ever-increasing technology demand. Further, moving away from nuclear energy before renewables are ready will cause decades of environmental progress to regress.

Nuclear energy must be part of the plan to reach the climate goals of the Paris Agreement, and to attain a CO_2-free energy future. While this plan will not solve climate change in its entirety, this policy objective will make a substantial impact in curbing the wretched impact that climate change is capable of unleashing on every living being on the planet. Countries should order nuclear energy for the table. Please.