ARGUMENTS AGAINST THE PRICE ANDERSON ACT

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PROLOGUE

Imagine a nuclear accident has occurred in your community. The air, water, and ground are all toxic. Your property has become worthless overnight – or worse, a contaminated liability. If you were able to, you got out in time, but all of your possessions were irradiated, as they had to be left behind. If you were near the incident, you might have inhaled Iodine-131, Cesium-137, Strontium-90, or drank tritiated water. Cancer may be beginning its assault on your lungs, bone marrow, or breasts. You may have lost loved ones. Perhaps your home was irradiated, and now you must move for your family's safety, and cannot find any buyers. Perhaps you own a farm and all your crops must be destroyed, the land unusable until (or if) it can be decontaminated. Maybe your entire herd of cows produce irradiated milk that you can't sell because it would give children thyroid cancer. Perhaps any number of additional toxic consequences occur.

Theoretically, you and your neighbors could sue the company for negligence, receive compensation, and try to put your lives back together. You earned your property; you grew your business; you worked hard for it, and it should be protected. But if the company is Exelon or any other nuclear utility, the Price Anderson act limits your compensation. After the first tier of $450 million and second tier of $12.9 billion are paid out[1] – if you're one of the 8 million people living within 50 miles of Exelon's Dresden plant in Morris, that's $161.30 each[2] – your compensation for an incident where the company's responsibility is not in question would be dependent on the United States Congress. At a time when Congress cannot agree on science-backed public safety measures like vaccines and masks, and raising the debt ceiling has become a predictable yearly fight, can we expect Congress to properly compensate the public in case of a nuclear incident?

I live in Illinois, so I have these questions.

INTRODUCTION

In 1954, Congress declared "[a.] the development, use, and control of atomic energy shall be directed so as to **make the maximum contribution to the general welfare**, subject at all times to the paramount objective of making the **maximum contribution to the common defense and security**; and [b.] the development, use, and control of atomic energy shall be directed so as **to promote world peace**, **improve the general welfare, increase the standard of living**, and **strengthen free competition in private enterprise**."[3]

At present, in 2021, we face a different world. We already have an enormous nuclear arsenal; which we have used to devastate 2 cities, various pacific islands, and our own desert, and project an image of strength in decades of brinkmanship during the Cold War. Whereas

1. NRC, BACKGROUNDER ON NUCLEAR INSURANCE AND DISASTER RELIEF (May 3, 2019) https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/nuclear-insurance.html.
2. Clark Merrefield et al., *Most Vulnerable U.S. Nuclear Plants*, DAILY BEAST (Mar. 15, 2011, 7:26 PM) http://www.thedailybeast.com/articles/2011/03/16/nuclear-power-plants-ranking-americas-most-vulnerable.html
3. Atomic Energy Act of 1954, 42 U.S.C. §§ 2011-2259 (originally enacted as 42 U.S.C. 1801). Author's emphasis.

attack from a foreign power was the former paradigm of war, today's battles have shifted, encompassing ideological terrorism and sophisticated state-backed cyberattacks. Internal threats abound as well: white domestic insurrectionists, disgruntled employees 'going postal,' and increasing frequency of natural disasters are potentially more catastrophic when nuclear material is nearby. Meanwhile, reactors have been aging, increasing the likelihood of breakdown and deterioration – and forcing communities located near reactors to carry a disproportionate amount of risk. Rather than contribute to the general welfare and common defense and security, these factors make nuclear reactors a risk to our welfare, defense, and security. Furthermore, nuclear energy is no longer competitive economically, as EIA projections and data from Illinois agencies shows. Continued government support of nuclear energy goes against the purpose of the Atomic Energy Act as it interferes with the energy market and stifles competition of cheaper, faster, fuel-less wind and solar energy, energy efficiency, and demand response.

It's time to reconsider both the purpose and the economic viability of subsidizing the nuclear industry for incidents caused by its operations. The dual purposes of the Price Anderson act were: 1) "Remove the deterrent to private sector participation in atomic energy presented by the threat of potentially enormous liability claims in the event of a catastrophic nuclear accident," and 2) "Ensure that adequate funds are available to the public to satisfy liability claims if such an accident were to occur."[4] At present, this guarantee of protection is illusory. As this paper will show, a major nuclear incident such as Fukushima (with no detectable civilian health effects) would generate damages far above the limit contemplated by the act. Rather than ensure compensation to the public, the limit on liability does the opposite – leaving communities near plants shouldering a risk that would be more appropriately carried by the private nuclear investors running the plants. Regarding private investment in nuclear energy, there is no longer a reason it should be encouraged. The Atomic Energy Act was designed to address cold war tensions, and it did so successfully. Now, nuclear energy is one of the most expensive types to generate, and it has externalities of unknown costs that cannot be calculated (like what to do with spent fuel). The destructive horror the atomic race seems quaint compared to fears of chemical releases caused by terrorism or natural disasters. Furthermore, a new fear has emerged that Eisenhower did not anticipate: slow irradiation of communities over decades, leading to health effects that are harder to conclusively link to their causes. Much like 70-year old technology, **the limitation of liability in the Price Anderson Act has outlived its usefulness. Is not in the best interest of the public, and should not be renewed.**

BACKGROUND

The Price-Anderson Nuclear Industries Indemnity Act of 1957 removed a substantial barrier to private sector participation in the nuclear industry by ensuring availability of about $13 billion in omnibus coverage from pooled insurance to compensate members of the public who incur damages from nuclear or radiological incidents.[5] Congress originally intended the Act to be an interim measure, as it had hoped the insurance industry would eventually step up.[6] Wall

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4. P.BAILEY ET AL., THE PRICE-ANDERSON ACT – CROSSING THE BRIDGE TO THE NEXT CENTURY: A REPORT TO CONGRESS, DOC NO. NUREG/CR-6617, Oct. 1998, https://www.nrc.gov/docs/ML1217/ML12170A857.pdf at 14
5. NRC, BACKGROUNDER ON NUCLEAR INSURANCE AND DISASTER RELIEF *supra* note 1. Nuclear energy operators (and suppliers, construction companies, etc.) enjoy federal limitations on liability in the case of an accident CTR. FOR NUCLEAR SCI. & TECH. INFO., THE PRICE-ANDERSON ACT 1–2 (Nov. 2005), http://www.ans.org/pi/ps/docs/ps54-bi.pdf.
6. Diane Curran & Scott Denman, Presentation at Vermont Law School Class: America's Energy Crisis (July 25,

Street was not interested, however, as the liability was (and is) too great.[7] For example, in the absence of a national repository, every reactor has spent fuel stored on site—if the water level ever drops in just one of these pools, the resulting fire could lead to over $56 billion in damages—multiple times the federal limit.[8] Under the Act's 2005 revision, reactor licensees are required to purchase the maximum amount of insurance available on the private market (about $450 million today) and contribute up to $95.8 million per reactor to a secondary insurance pool (which is not paid in until required).[9] In the event of a nuclear incident exceeding $10 billion in damages, Congress would have to appropriate additional funds in order to compensate victims.[10] Because it limits liability and drives down the cost of borrowing for nuclear companies, the Price-Anderson Act is an entrenched federal nuclear subsidy.[11]

The 1960s brought an increase in environmental regulation, including the National Environmental Policy Act, which together with the rising cost of capital and fuel has made nuclear plants less economical than anticipated.[12] The industry was already in decline when, in 1979, the Three Mile Island Unit 2 reactor in Pennsylvania malfunctioned, leading to a severe core meltdown.[13] Although the small radioactive releases had no effect on plant workers or the public, the incident put an economic chill on the burgeoning nuclear industry.[14] Increased regulatory oversight after the accident contributed to increased environmental assurances but also increased costs.[15] Production tax credits and loan guarantees in the new millennium led to a nuclear renaissance in the early 2000s, which seemed to be collapsing a decade later as actual costs exceeded prior estimates.[16]

COSTS OF NUCLEAR DEVELOPMENT

In its 2021 Annual Energy Outlook, the Energy Information Administration compares construction costs, fixed operating and maintenance costs, and lead times for various forms of energy generation (and battery storage). [17] With the exception of fuel cells (and solar thermal before investment tax credits are applied), nuclear reactors – light water and small modular – were the most expensive forms of energy to build, with base overnight costs of over $6,000/kW.[18] In comparison, Solar PV with tracking (tilting throughout the day for best sun

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2014).

7. *Id.*

8. *Id.*

9. NRC, BACKGROUNDER ON NUCLEAR INSURANCE AND DISASTER RELIEF *supra* note 1 and CTR. FOR NUCLEAR SCI. & TECH. INFO, *supra* note 5.

10. CTR. FOR NUCLEAR SCI. & TECH. INFO, *supra* note 5, at 2.

11. Curran & Denman, *supra* note 6.

12.INT'L ATOMIC ENERGY AGENCY, NUCLEAR TECHNOLOGY REVIEW 2004, at 46–47 (Aug. 2004), https://www.iaea.org/About/Policy/GC/GC48/Documents/gc48inf-4_new.pdf.

13. *Id*. at 47; *Three Mile Island Accident*, BACKGROUNDER (U.S. Nuclear Reg. Comm'n Office Pub. Affairs), Feb. 2013, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.pdf.

14. Duquesne Light Co. v. Barasch, 488 U.S. 299, 299 (1989).

15. *Three Mile Island Accident*, *supra* note 13, at 3.

16. Curran & Denman, *supra* note 6.

17 ENERGY INFORMATION ADMINISTRATION, COST AND PERFORMANCE CHARACTERISTICS OF NEW GENERATING TECHNOLOGIES, ANNUAL ENERGY OUTLOOK 2021 (Feb. 2021), available at https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf at 2.

18. *Id.*

reception) costs $1,248/kW and onshore wind costs $1,846/kW to build.[19] The lead times for nuclear are the longest on the list: 6 years, compared to 2 and 3 for solar and wind, respectively.[20] Battery storage is even more appealing: One year lead time, with base overnight costs of $1,165/kW.[21] America long mythologized the atomic age as futuristic. Yet today, in the future, nuclear fission is not a cheap form of energy to build. Cheaper, faster energy and better-designed load serving entities abound.

In a 2015 legislative report by Illinois agencies, entitled *Potential Nuclear Plant Closings in Illinois: Impacts and Market-Based Solutions*, the Illinois Commerce Commission found that in a "worst-case scenario," (no Clean Power Plan), the Quad Cities units would need rates to increase nearly 50% to get back to the 2007-13 average.[22] It was "not entirely clear," due to limited data, whether or not Exelon's Illinois plants "earn sufficient revenues to cover their operating costs."[23] The ICC produced a chart of the price increases needed to restore profitability to each plant (Figure 1).[24] It found that every reactor at all six plants studied would require a price increase in order to break even to the 2007–2013 average.[25]

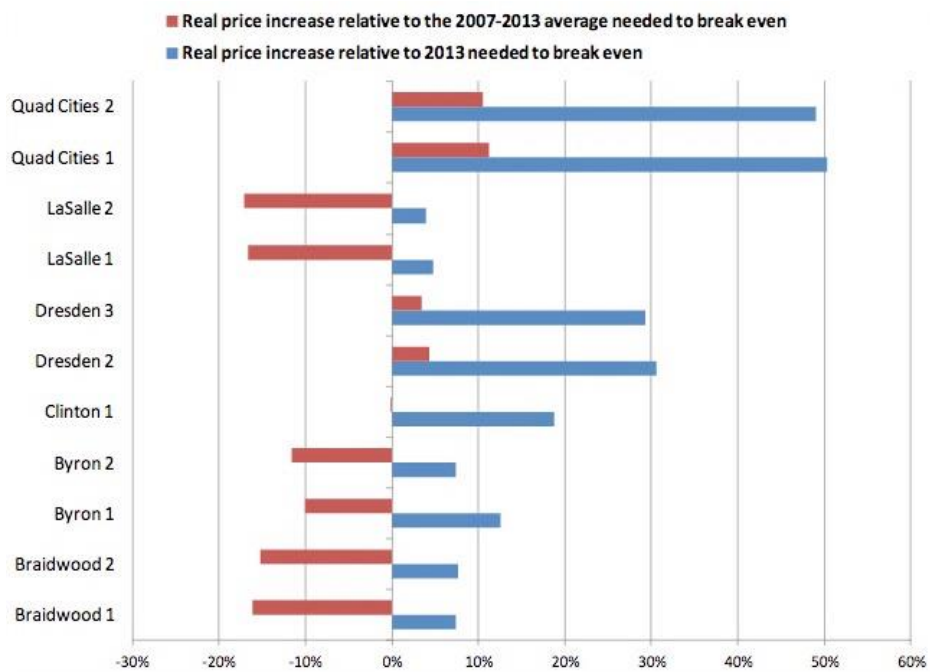

Figure 1. Real Price Increases Required to Equal EPA-Modeled Production Costs[26]

19. *Id*.
20. *Id*.
21. *Id*.
22. ILL. COM. COMM'N ET AL., POTENTIAL NUCLEAR POWER PLANT CLOSINGS IN ILLINOIS: IMPACTS AND MARKET-BASED SOLUTIONS 5, 27 (Jan. 5, 2015) at 40. http://www.ilga.gov/reports/special/Report_Potential%20Nuclear%20Power%20Plant%20Closings%20in%20IL.pdf.
23. *Id*.
24. *Id* at 39–40.
25. *Id* at 40.
26. *Id*.

The energy information administration offers no calculations for the environmental effects of electricity generation. Nor does the Illinois report justifying its Zero Emission Standard include any assessment of nuclear energy's health or environmental effects. These are externalized: carried by society as a whole. Environmental problems associated with nuclear energy – such as cancer in uranium mine workers, tritium leaked into groundwater, and the dangers of storing nuclear waste - are not accounted for in the price of electricity.[27] This is a market failure, as it does not adequately value clean water and air, two necessities for life.[28] "Environmental problems are not, therefore, exceptional or accidental" observed geographer David Humphreys; "they are the cumulative result of routine social actions."[29] Rational investors wishing to make a profit will not concern themselves with the polluting effects of their industry if they are not required to. "Conventional energy systems, unfortunately, appear to be designed to…maximize externalities."[30]The purpose of a regulatory commission such as the NRC should be to help ensure these externalities are properly paid for by the companies that cause them. Indemnification does the opposite – sending the message that safety of the communities located near nuclear reactors is not as important as the industry's profits.

Mining the 25 tons of uranium necessary to power a fission reactor for a year creates 500,000 tons of waste rock, 100,000 tons of mill tailings (toxic for hundreds of thousands of years), 144 tons of solid waste and 1,343 cubic meters of liquid waste.[31] Radionuclides uranium-253, radium-226, and strontium-21 accumulate in the radioactive dust inhaled by miners, causing lung cancer.[32] According to the International Commission on Radiological protection, uranium mining associated deaths range from 5,500 to 37,500 per million workers per year.[33] In the United States, the experience of those who worked at the Shiprock facility in New Mexico shows how lethal uranium mining is: of 150 miners, 38 died of radiation-induced cancer and 95 had serious respiratory illnesses or cancer.[34] On closing, the facility left 70 acres of untreated tailings, an externality borne by the community. Since 1995, the government has paid $1.3 billion in 28,000 claims to uranium miners living downwind of nuclear test sites and mines who had been unwittingly exposed to radiation, and then studied without knowledge or consent.[35]

The U.N. has reviewed studies of uranium miners around the world, as radon and its progeny are established carcinogens for the lung, and the workers' inhalation adds up to substantial doses.[36] An updated study following a group of over 4,000 men who had worked at least one month in a Colorado uranium mine from 1950 to 1960 calculated a standardized mortality ratio of 3.99 for white miners (and 3.27 for Native American miners).[37] In 2019 UNSCEAR calculated combined excess relative risk (ERR) estimates per 100 workers, finding an average of .60 for all studies included, and a higher ERR of 1.53 when it considered more

27. BENJAMIN K. SOVACOOL ET AL., ENERGY SECURITY, EQUALITY, AND JUSTICE, 57 (2015)
28. *Id.*
29. *Id,* citation omitted.
30. *Id* at 59.
31. *Id* at 67
32. *Id* at 68.
33. *Id,* citation omitted.
34. *Id.*
35. *Id.*
36. U.N. Scientific Committee on the Effects of Atomic Radiation; Sources, Effects and Risks of Ionizing Radiation UNSCEAR 2019 Rep. to the General Assembly, Scientific Annex B, ¶ 1, U.N. Doc A/74/46; GAOR, 74th Sess., Supp No. 46 (Dec. 2020) at 195.
37. *Id* at 217-8.

recent work periods and lower exposures.[38] More research into different models is necessary, as the current model's assumptions "include over-simplification of the underlying processes."[39]

One oft-overlooked externality of nuclear energy is greenhouse gas emissions. Processes such as mining, milling, leaching, plant construction, and decommissioning are greenhouse gas intensive, and coal power plants often generate the energy for reprocessing and enriching uranium.[40] Average CO_2 emissions over a nuclear plant's lifetime are about 66 grams per kWh.[41]

The storage of nuclear waste is also an externality, "because it imposes severe costs on future generations."[42] Whereas a catastrophe is speculative, irradiated fuel is a certainty. Illinois remains host to more irradiated nuclear fuel than any other state, stored on site at the 7 nuclear plants and in the GE-Morris storage facility (which had been built as a reprocessing center). [43] Thirty three other states are also storing spent nuclear fuel, at 76 reactor sites.[44] At California's San Onofre State Beach, 3.6 million pounds of it lie in a concrete enclosure 1000 feet from the shoreline. The location is under a highway, on the coast, and not far from 2 faults that could cause an earthquake.[45]

Technically, long-term disposal is the government's responsibility. The 1982 Waste Policy Act outlined the steps towards selecting and constructing a national repository, but it wasn't until 2016 that the NRC published its final safety report for permanent nuclear waste storage at Yucca Mountain (which has since been abandoned).[46] In 1984, the NRC concluded in a "Waste Confidence" proceeding that the Commission did not need to consider the environmental impacts of on-site storage of spent fuel when issuing or amending operating licenses.[47] At the time, it was reasonably certain that a geologic repository for high-level waste would be available by 2025, and that a reactor could store used material on site for thirty years without any significant environmental impacts.[48]

It has been over thirty years since that determination. Although industry is responsible for interim fuel storage under the WPA, plant operators have filed over sixty lawsuits in the U.S. Court of Federal Claims over the Department of Energy's failure to accept spent nuclear fuel, in violation of its standard reactor contract that said it would begin accepting fuel in 1998.[49] Exelon settled with the Department of Energy, receiving $80 million in damages and ongoing

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38. *Id* at 255.
39. *Id.*
40. SOVACOOL ET AL. *supra* note 27 at 61.
41. *Id* at 62.
42. *Id* at 69.
43. *What Is Spent Nuclear Fuel?* ILLINOIS EMERGENCY MANAGEMENT AGENCY – DIVISION OF NUCLEAR SAFETY https://www.illinois.gov/iema/Info/Documents/IEMA%20035-What%27s%20Spent%20Fuel.pdf Technically, irradiated fuel is not "spent" but retains most of its energy, and can be reprocessed, as in France and Japan.
44. Kate Mishkin, *'A Combination of Failures:' Why 3.6m Pounds of Nuclear Waste is Buried on a Popular California Beach,* Guardian, Aug.24,2021, https://www.theguardian.com/environment/2021/aug/24/san-onofre-nuclear-power-plant-radioactive-waste-unsafe.
45. *Id.*
46. *Disposal: Yucca Mountain Repository*, NUCLEAR ENERGY INST., https://www.nei.org/Issues- Policy/Used-Nuclear-Fuel-Management/Disposal-Yucca-Mountain-Repository
47. JAY M. GUTIERREZ & ALEX S. POLONSKY, FUNDAMENTALS OF NUCLEAR REGULATION IN THE UNITED STATES 3–7 (2d ed. 2007) at 84, 216–17.
48. *Id.*
49. *Id* at 216, 220.

additional compensation for approved spent fuel storage costs each year.[50] This is yet another cost paid by taxpayers, not factored into energy development. Meanwhile fuel remains stored in its temporary locations across the State, vulnerable to natural disasters, terrorism, or the first ICBM of WWIII. Nuclear Waste management "was not a big topic at the NRC" according to former commission chair Allison Macfarlane.[51] "In the nuclear industry in general the backend of the nuclear cycle gets very little attention. So it just never rises to 'oh this is a very important issue, we should be doing something.'"[52]

Another environmental concern is aging pipes that could leak radioactive tritiated water into the groundwater supply. [53] Tritiated waste cooling water from Exelon's Braidwood plant leaked roughly 8 times during its 1.5-mile trek to the Kankakee River from roughly 1996 to 2000. Exelon failed to report the leaks until 2005. Tritium, a radioactive isotope of hydrogen, easily replaces its non-radioactive form in water molecules, and can increase one's risk of cancer. Once entering the body, most of it disperses within 10 days, but 10 percent is retained as organically bound tritium.[54]

The Federal Government does not view unreported groundwater contamination as a particularly severe threat. After a 2010 Groundwater Task Force recommended turning voluntary industry standards into a regulatory framework, the Nuclear Regulatory Commission decided not to, finding that the industry's response was largely consistent with voluntary regulations.[55]

What about slow releases, and long-term low level exposure? In Fundamentals of Nuclear Regulation in the United States, Gutierrez and Polonsky note that Price Anderson's terms of coverage "initially drafted premised on the occurrence of an extraordinary nuclear event – will need to respond to the more probable claim from the long-time worker that his or her cancer was induced by exposure incidental to normal plant operations."[56] Pointing to the bomb-testing studies' limited applicability to current modern nuclear releases, they note that "it will be increasingly difficult to establish the theory of causation" for plant workers, and that "the current theories and existing systems to compensate claims of injury resulting from exposure to radiation are ripe for reconsideration."[57]

In 2010, the NRC asked the National Academy of Sciences (NAS) to study the cancer risks of living near a nuclear power plant or fuel processing facility.[58] In the first phase of the study, the NAS recommended studying cancers, mortality, and childhood cancers within thirty

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50. *Id* at 220.
51. Mishkin, *supra* note 44.
52. *Id.*
53. Press Release, Illinois Att'y Gen. Lisa Madigan, Madigan, Glasgow File Suit for Radioactive Leaks at Braidwood Nuclear Plant: Leaks of Tritium-Laced Wastewater Date to 1996 (Mar. 16, 2006), http://www.illinoisattorneygeneral.gov/pressroom/2006_03/20060316.html.
54. *Tritium, Radiation Protection Limits, and Drinking Water Standards*, BACKGROUNDER (U.S. Nuclear Reg. Comm'n Office Pub. Affairs), Feb. 2016 at 2
55. Memorandum from R.W. Borchardt, Exec. Director for Operations, to the Commissioners of the NRC, on the Senior Management Review of Overall Regulatory Approach to Groundwater Protection (Feb. 9, 2011), https://www.nrc.gov/reading-rm/doc-collections/commission/secys/2011/2011-0019scy.pdf at 3.
56. GUTIERREZ & POLONSKY, *supra* note 47 at 229
57. *Id.*
58. *Analysis of Cancer Risks in Populations Near Nuclear Facilities*, BACKGROUNDER (U.S. Nuclear Reg. Comm'n Office Pub. Affairs), Jan. 2016, at 2, http://www.nrc.gov/docs/ML1326/ML13269A432.pdf. Illinois is home to the country's only active uranium processing facility, in Metropolis, near the southern tip of the state. *Honeywell Metropolis Works*, HONEYWELL, http://www.honeywell-metropolisworks.com/ (last visited Feb. 19, 2017).

miles of nuclear facilities.[59] It also recommended computer modeling to estimate radiation doses from airborne and liquid releases.[60] In 2014, the NAS reported that completion of the pilot study would take three years and $8 million and "will have limited use for estimating cancer risks . . . because of the imprecision inherent in estimates from small samples."[61] The NRC ended the study, concluding that "the time and money would not be well spent for the *possible* lack of useful results."[62] The shift in government attitude since the atomic enthusiasm of 1950s is notable. Eisenhower might have rallied the entire country's oncologists, statisticians, and mathematicians to improve methods of cancer incidence detection in populations. The NRC's apathy runs against the stated purposes of atomic electricity, to enhance Americans' welfare and security. Statistical modeling is constantly improving, as the UN radiation studies showcase. But if it is too expensive and time-consuming to even research the effects of radiation on American populations, then there is no justification for subsidizing continued nuclear energy generation. We have plenty of other energy options.

As plants get older, their equipment ages and risk of other such incidents increase. But health and safety of nuclear energy regulation are not the purview of the state – Vermont found this out when its legislature sought to close its nuclear plant. [63] A Federal Appeals court affirmed that State nuclear safety laws are pre-empted by the Federal Government. (No such prohibition applied to a California law suspending State certification of nuclear plants until the cost of disposing of radioactive waste could be determined.[64] Yet, as noted above, Californians still shoulder the environmental burden of the waste.) As a citizen, I filed Freedom of Information Act Requests with my local state emergency management and environmental agencies and they had no information to assuage me they have prepared for potential nuclear incidents, or contamination from spent fuel. That's Exelon's responsibility, I was told.

The NRC should be regulating the environmental releases at power plants, ensuring that the externalities are internalized – shouldered by the industry, rather than non-consenting members of the public. Instead, it has granted permission to plants like Southern California Edison (the operator of the San Onofre Nuclear Generating Station) to loosen rules regarding record-keeping, radiological emergency plans, emergency planning zones, and on-site staffing.[65] According to former NRC chair Gregory Jaczko: "If the NRC is regulating by exemption, it means that there's something wrong with the rules…either the NRC believes the rules are not effective, and they're not really useful, or the NRC is not holding the line where the NRC should be holding the line."[66] The Union of Concerned Scientists' former nuclear safety project director David Lochbaum offers a different perspective: "Exemptions are wink-wink, nudge-nudge deals with the NRC."[67] Retired admiral Len Hering, who in 2005 received an award of leadership in federal energy management from President George W Bush, came to a similar conclusion: "**The problem you have here is that the NRC is simply not doing its job as a regulator.** So what it

59. *Analysis of Cancer Risks in Populations Near Nuclear Facilities*, BACKGROUNDER
60. *Id.*
61. *Id.* at 3.
62. *Id.* (emphasis added).
63. Energy Nuclear Vt. Yankee, LLC v. Shumlin, 733 F.3d 393, 398 (2d Cir. 2013)
64. Pac. Gas & Elec. Co. v. State Energy Res. Conservation & Dev. Comm'n, 461 U.S. 190, 212 (1983).
65 Mishkin, *supra* note 44
66. *Id.*
67. *Id.*

has done is allowed the industry to basically determine the conditions under which this material is stored..."[68]

Gutierrez and Polonsky describe the NRC as "an agency pulled by many competing influences."[69] The purpose of an independent regulatory agency, ideally, is to be free "from the political influences of the executive branch and the appointment process."[70] The "very political consequence" is that independent agencies report to different congressional committees and subcommittees (each with their own agenda), leaving such agencies under political influence from Congress.[71] Another influence on regulators is likely that they often come from industry. Where else is one to develop the expertise (and security clearances) to understand nuclear energy development at a granular level?

A 2019 Office of the Inspector General audit found eliminating exemptions could save the NRC, utilities, and taxpayers $19m for each reactor.[72] In an era where the federal government is struggling to fund the basic health needs of its citizens, and even to fund itself, fines from noncompliance could be an important source of revenue from utilities. Just because Exelon or Southern California Edison doesn't have to pay a cost of their energy production, does not mean it disappears. These costs of nuclear energy will be borne by the public, now or in the future. As an energy regulator, the NRC is obligated to manage these externalities: to ensure the cost of nuclear energy generation reflects its risks and liabilities. In every other industry, torts and insurance fill this gap – and the insurance industry does well for itself. If the investors and accountants of every major insurance company in America, including the American Nuclear Insurers, have concluded that insuring nuclear energy to its full risk potential would not be a profitable enterprise, then we as attorneys would be abandoning our obligation to the public and the future if we said 'Sure, go ahead and build it/run it/dump it anyways.'

My Global Energy Justice professor[73] Benjamin Sovacool has explained how the prohibitive principle of energy justice should be considered in energy decision-making: "Energy systems should be designed so as not to interfere unduly with the ability of any human being to acquire the basic goods to which he or she is justly entitled."[74] In other words, "energy systems should be designed so as to minimize externalities."[75]

NUCLEAR ENERGY EMERGED AS A COLD WAR DISARMAMENT SOLUTION; MODERN GLOBAL THREATS REQUIRE A PARADIGM SHIFT.

When it passed the Price-Anderson Act in 1957, the United States Congress had little experience with nuclear energy and its effects. At the time, there had been no major nuclear accidents. Much knowledge of radiation stemmed from its effect as the most powerful weapon ever used: a decade earlier, the U.S. had dropped two atomic bombs on Hiroshima and Nagasaki with the intention of killing hundreds of thousands of civilians in the most horrific way

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68. *Id.*
69. GUTIERREZ & ALEX S. POLONSKY, *supra* note 47 at 8.
70. *Id.*
71. *Id.*
72. Mishkin, *supra* note 44 (citation omitted).
73. Vermont Law School, 2014
74. SOVACOOL et al., *supra* note 27 at 59.
75. *Id.*

imaginable. Casualties were hard to estimate because the heat and energy completely vaporized people who were near the hypocenters, and many sought relief in rivers that carried their bodies out to sea. [76] The anime movie Barefoot Gen tries to capture the devastation after Hiroshima through a young boy's perspective: skin melts off the multitudes who survived the blast, and as they crawl up to Gen they all ask for one thing: water. [77] Yet as soon as they drink it, they fall down and die. The world had entered a terrifying new age.

By 1953, the Soviet Union had also begun experimenting with nuclear weapons. "If at one time the United States possessed what might have been called a monopoly of atomic power, that monopoly ceased to exist several years ago," noted President Dwight Eisenhower in his 'Atoms for Peace' address to the United Nations: [78]

> The knowledge now possessed by several nations will eventually be shared by others, possibly all others…let no one think that the expenditure of vast sums for weapons and systems of defense can guarantee absolute safety for the cities and citizens of any nation. The awful arithmetic of the atomic bomb does not permit of such an easy solution.[79]

Eisenhower worried of "The hopeless finality of a belief that two atomic colossi are doomed malevolently to eye each other indefinitely across a trembling world…the probability of civilization destroyed, the annihilation of the irreplaceable heritage of mankind handed down to us from generation to generation."[80] The U.N. worried as well, and in November 1953 had suggested the Disarmament Commission consider establishing a sub-committee consisting of representatives of the powers involved and seek an acceptable solution in private and report back by 1 September 1954.[81] "It is not enough," responded Eisenhower, "to take this weapon out of the hands of the soldiers. It must be put in the hands of those who will know how to strip its military casing and adapt it to the arts of peace."[82] Backed against a deadline by the U.N., and under the looming threat of a nuclear apocalypse, one human being suggested an idea. "Who can doubt," he proclaimed boldly, "that, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, this capacity would rapidly be transformed into universal, efficient, and economic usage."

It may have been inopportune to doubt nuclear energy in 1954, but 65 years later, the entire body of the world's scientists and engineers have been unable to keep nuclear energy affordable. Yet they have had enough fissionable material – and more continues to be mined and processed.

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76. Dennis Normille, How *Atomic Bomb Survivors Have Transformed Our Understanding of Radiation's Impact,* SCIENCE, Jul, 23, 2020, https://www.sciencemag.org/news/2020/07/how-atomic-bomb-survivors-have-transformed-our-understanding-radiation-s-impacts.
77. BAREFOOT GEN (Gen Productions and Madhouse, 1983) (Adapted from the manga Hadashi no Gen by Keiji Nakazawa).
78. U.S. President Dwight D. Eisenhower, Address to the 470th Plenary Meeting of the U.N. General Assembly: Atoms for Peace (Dec. 8, 1953).
79. *Id.*
80. *Id*.
81. *Id*.
82. *Id*.

Eisenhower solved the immediate problem of fear of nuclear annihilation by heralding a shift to internationally cooperative nuclear energy development. However, he did not even consider the environmental effects of leaks, airborne releases, and meltdowns that we have seen in the decades since. Both routine nuclear waste products and occasional disasters have fueled a new problem - decontamination – which is both environmental and economic. Though originally intended to enhance Americans' health and security, and provide cheap energy; continued use of aging nuclear reactors without solving their intractable problems endangers Americans' health, security, and pocketbooks.

HEALTH COSTS OF RADIATION EXPOSURE

In nuclear fission, the nuclei of atoms are bombarded until they split, producing gamma photons and various unstable isotopes which give off ionizing radiation as they spontaneously decay. Ionizing radiation, explains the National Cancer Institute, consists of subatomic particles and electromagnetic waves, which have enough energy to strip electrons from atoms in the molecules they strike.[83] It is well understood today that ionizing radiation is a carcinogen at even low doses, as it causes cancer by damaging DNA.[84] Children (and especially fetuses) are more at risk to the cancer-causing effects of ionizing radiation since their bodies are still developing.[85]

In the 21st century, our understanding of radiation and disease is becoming more complex. Advancements in disease detection and statistical analysis have allowed for a better understanding of radiation's effects. Studies have followed atomic and hydrogen bomb survivors, Chernobyl residents, nuclear workers, and babies who have had CT scans. A specific radionuclide can be linked to a specific type of cancer. Governments have become more transparent about nuclear incidents and effects (but not entirely – radiation monitoring in 2017 detected a sizeable release of radioactive Ruthenium 106, which a study from a group of European scientists pinpointed to the southern Urals, likely the Russian Mayak facility, possibly from reprocessing spent nuclear fuel for neutrino applications.)[86] Nonetheless, uncertainty abounds; the cause of a cancer is much more difficult to prove than, say, a broken leg. Studies must account for participants' diets, occupations, and family medical histories. Additionally, the unstable nature of nuclear reactions means our prior experience isn't necessarily indicative of all possible outcomes.

Scientists' understanding of the effects of radiation began with studies of the residents of Hiroshima and Nagasaki who survived the atomic bombings. The Atomic Bomb Casualty Commission, set up by the Truman administration, studied health effects and possible heritable genetic effects of atomic bomb survivors and their families. (Heritable mutations are of particular

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83. *Accidents at Nuclear Power Plants and Cancer Risk*, NATIONAL CANCER INSTITUTE, https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/nuclear-accidents-fact-sheet (last visited Aug. 18, 2021)
84. *Id*.
85. *Id*.
86. Masson et al., *Airborne Concentrations and Chemical Considerations of Radioactive Ruthenium From an Undeclared Major Nuclear Release in 2017*, NATIONAL ACADEMY OF SCIENCES, Aug. 20, 2019, https://www.pnas.org/content/116/34/16750#ref-1.

interest due to the gene-transforming abilities of radiation.) The ABCC found that many of the survivors suffered leukemia, an otherwise rare disease at the time.[87] Reformed in partnership with Japan to become the Radiation Effects Research Foundation, it continues to study survivors and their children. For the 124 survivors who were within 900 meters of the epicenter, received over 2 grays of radiation, and later died of cancer, RERF found 56.5% (70) of the deaths were attributable to radiation.[88] At 1 gray or 1100 meters, the attributable percent is 34.8 percent, decreasing linearly for lower doses. Women were more likely to get cancer than men, due to many cases of breast cancer. "Radiation most increased the risk of leukemia among survivors, followed by cancer of the stomach, lung, liver, and breast…Exposure also heightened the risk of heart failure and stroke, asthma, bronchitis, and gastrointestinal conditions."[89] Sixteen percent of noncancer deaths in survivors with 2-gray exposure were attributable to radiation.[90] Additionally, RERF found "radiation-related risk may have been higher in women who were younger at the time of the accident and/or at the time of diagnosis."[91] Those who were younger at the time of exposure had a greater risk of developing cancer, with new research showing those exposed at puberty were at a higher rate of reproductive cancer later in life.[92]

The 1986 Chernobyl disaster remains the most terrifying demonstration of the dangers a nuclear plant poses to workers and the public. Around 600 plant workers died from radiation sickness; those with over 6 grays (Gy) of exposure becoming very sick immediately.[93] Hundreds of thousands in the cleanup crews were exposed to lower doses (.14 to .04 Gy), and among this group there was an increased incidence of Leukemia.[94] Lack of knowledge about the dangers of radiation, along with failure to inform the large surrounding population, caused unnecessary death and illness and have given Chernobyl the rank of worst nuclear energy disaster in history.

The list of dangerously reactive chemicals produced in nuclear reactors spans over 100.[95] Radioactive isotopes released and studied in past nuclear meltdowns have included iodine-131, cesium-137, strontium-90 and plutonium-239; the disaster at Chernobyl has provided an opportunity to study the first three.[96] Cesium 137 harms the body through external or internal exposure – contact with contaminated materials, breathing contaminated air or eating contaminated foods- and can damage all tissues.[97]

Iodine 131 can contaminate air, water, and food, particularly milk from cows grazed on contaminated grass.[98] In humans, it burns the skin and eyes, and accumulates in the thyroid

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87. Normille, *supra* note 76.
88. *Id*.
89. *Id*.
90. *Id*.
91. *Id.*
92. *Id*.
93. NATIONAL CANCER INSTITUTE, *supra* note 83
94. *Id.*
95. SOVACOOL et al., *supra* note 27 at 69.
96. NATIONAL CANCER INSTITUTE, *supra* note 83
97. *Id.*
98. *Radionuclide Basics: Iodine 131*, U.S. EPA, https://www.epa.gov/radiation/radionuclide-basics-iodine (last accessed Aug. 22, 2021)

gland, which needs iodine to produce hormones that control how the body uses energy.[99] Children exposed to ^{131}I in the area around Chernobyl showed an increase in thyroid cancer, with each Gy of exposure doubling the risk. Though its half-life is 8 days, its effects on the body can last a lifetime: A NCI study following 12,500 children exposed to ^{131}I in the Chernobyl accident, found that half of the 65 thyroid cancer cases developed between 1998 and 2007 were caused by ^{131}I exposure.[100]

Strontium-90 is tasteless, odorless, and invisible –and remains radioactive for 600 years.[101] Because it takes so long to break down, it concentrates in the food chain. When it enters the body, it mimics milk, building up in bones and lactating breasts, and causing breast cancer, bone cancer, and leukemia.[102] Children and babies are 10-20 times more susceptible to ^{90}S than adults.[103]

Plutonium, considered to be a man-made element, was discovered in 1940 by scientists developing the atomic bomb. [104] In the U.S., light water nuclear reactors create plutonium isotopes as a byproduct of uranium fission reactions, though in other countries plutonium isotopes begin nuclear chain reactions.[105] Plutonium has five common isotopes with varying lifespans: Pu-239, the isotope most commonly formed in a nuclear reactor, has a half-life of 24,100 years; Pu-232 has a half-life of 374,000 years; Pu-238 has a half-life of 88 years, and Pu-241 has a half-life of 14.4 years (meaning it will take that long for these molecules to stop emitting radiation). [106] (For some perspective, *Homo Sapiens* migrated to Europe and Australia 40,000 years ago.[107]) A 1000 MWe light water nuclear reactor will create about 25 tonnes of waste product annually, and plutonium may comprise up to 290 kg of this irradiated fuel.[108] Nuclear reactors "produce waste that will persist longer than our civilization has practiced Catholicism, longer than humans have cultivated crops, and longer than our species has existed."[109]

Tritium, a radioactive isotope of hydrogen, is naturally present in the atmosphere and widely dispersed from nuclear weapons testing during the cold war. Tritiated water can be found in spent fuel cooling ponds near nuclear reactors—and in underground pipes that carry water to the reactors.[110] Tritium emits low-energy beta particle radiation, which cannot penetrate skin, but

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99. *Id.* and NATIONAL CANCER INSTITUTE, *supra* note 83
100. NATIONAL CANCER INSTITUTE, *supra* note 83
101. SOVACOOL et al., *supra* note 27 at 69.
102. *Id.*
103. *Id* at 70.
104. *Backgrounder on Plutonium*, NRC (Jan, 2020) https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/plutonium.html.
105. *Id.*
106. *Plutonium*, WORLD NUCLEAR ASS'N (Apr. 2021) https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/plutonium.aspx#:~:text=Pu%2D240%2C%20fertile%20(half,alpha%20decay%20to%20U%2D236)
107. SOVACOOL et al, *supra* note 27 at 71
108. *Plutonium*, WORLD NUCLEAR ASS'N
109. SOVACOOL et al, *supra* note 27 at 71
110. Jeff Donn, *Radioactive Tritium Leaks Found at 48 US Nuke Sites*, TODAY.COM (June 21, 2011, 5:48 AM), http://www.today.com/id/43475479/ns/today-today_news/t/radioactive-tritium-leaks-found-us-nuke-sites/#.VXtEr-u7-60.

can still enter the body through drinking water. Since tritium emits all its energy near the end of its life, it has a higher density of ionization than other forms of radiation.[111] Data on the health effects of radiation are lacking. However, the National Institute for Occupational Safety and Health considers tritium to have an enhanced biological effectiveness when compensating energy workers who may have been exposed to it—indicating the U.S. Government's recognition that it has serious effects.[112]

Twenty thousand pCi/L (picocuries per Liter) is the EPA's standard for drinking water contamination by radionuclides, but some scientists think tritium deserves a higher standard.[113] Translating roughly to 20,000 pCi/L in water, four millirem absorbed by the body per year is the general standard for beta particle and photon radionuclides,[114] roughly equivalent to a chest X-ray.[115] The Environmental Radiation Protection Standards for Nuclear Power Operators, promulgated in 1977, limits the annual dose to any member of the public to twenty-five millirems to the whole body, seventy-five millirems to the thyroid, and twenty-five millirems to any other organ.[116] It also specifies a yearly limit per power plant on a variety of radioactive isotopes entering the general environment per gigawatt-year.[117]

In 2014, the EPA began revising its "Environmental Radiation Protection Standards for Nuclear Power Operations" regulations to include a section on water resources near nuclear facilities, but it has yet to introduce an update to the regulation.[118] The rule's final environmental statement in 1976 concluded that groundwater contamination was "not likely to be a pervasive problem" because "liquid pathway releases from these facilities result in much smaller potential doses than do noble gas releases [air releases]."[119] It remarked that "[d]etailed studies of several specific facilities have revealed no actual dose to any individual from this pathway as great as 1 mrem per year."[120] The proposed updates would also address issues of spent nuclear fuel, extension of reactor licenses, and new groundwater standards, to correct the erroneous assumptions in the original regulation.[121] Furthermore, they contemplate location-specific standards for groundwater near nuclear plants that may be used in the future as drinking water.[122]

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111. David Biello, *Is Radioactive Hydrogen in Drinking Water a Cancer Threat?* SCI. AM. (Feb. 7, 2014), http://www.scientificamerican.com/article/is-radioactive-hydrogen-in-drinking-water-a-cancer-threat/. For the same reason, it is also harder to monitor with current technology.

112. *Id.*

113. *See Tritium, Radiation Protection Limits, and Drinking Water Standards*, BACKGROUNDER (U.S. Nuclear Reg. Comm'n Office Pub. Affairs), Feb. 2016, https://www.nrc.gov/docs/ML0620/ ML062020079.pdf ("The EPA's dose-based drinking water standard of 4 mrem per year is based on a maximum contaminant level of 20,000 picocuries per liter (pCi/L) for tritium. If other similar radioactive materials are also present in the drinking water, the annual dose from all the materials combined shall not exceed 4 mrem per year.").

114. *Id.*; *see also How Is Tritium Regulated?*, EPA, https://safewater.zendesk.com/hc/en-us/articles/211 404908-How-is-tritium-regulated- (last visited Feb. 19, 2017) (describing tritium regulations in the United States).

115. Biello, *supra* note 111.

116. 40 C.F.R. § 190.10(a) (2016).

117. *Id.*

118. Environmental Radiation Protection Standards for Nuclear Power Operations, 79 Fed. Reg. 6509, 6509 (Feb. 4, 2014) (to be codified at 40 C.F.R. pt. 190).

119. *Id.* at 6519–20.

120. *Id.* at 6520.

121. *Id.* at 6513.

122. *Id.*

A 2019 study Russian women after long-term (about 25 years) radiation exposure from the Chernobyl accident found that "prolonged exposure to ionizing radiation at low dose rates can increase risk of breast cancer." [123] In the case-control study, over 400 women diagnosed between 2008 and 2013 were compared against women without cancer who all lived in Bryansk Oblast at the time of the Chernobyl disaster and the time of the diagnoses. Researchers estimated doses from diet and residence histories, and found the odds ratio for breast cancer risk to be 3.0 with a 95% confidence interval (an odds ratio of greater than 1 indicates an exposure is associated with an outcome).

In its 2019 report on the Sources, Effects and Risks of Ionizing Radiation, the U.N. Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) evaluated the excess risk that low to moderate radiation exposure creates for childhood leukemia, adult leukemia, solid cancer, and thyroid cancer; and the risk of higher doses of radiation on circulatory disease.[124] The Committee used atomic survivor studies, childhood CT scan data, the INWORKS study of male nuclear workers, and Chernobyl studies to evaluate radiation risks. It defined, as best as possible, a cumulative excess risk (number of excess deaths per population of 10,000) for 4 low to moderate radiation exposure scenarios. To highlight the uncertainty inherent in these calculations, the '95% credible interval' column shows the interval of the number of deaths that could be estimated with 95% confidence.

Figure 2. Rounded Values of Cumulative Cancer Risk Due to Radiation Exposures in the Preferred Risk Inferences[125]

Exposure scenario	*Cumulative dose*	*Follow-up*	*Cumulative excess risk (per 10 000 persons)*	
			Preferred risk inference	*95% credible interval*
Four CT scans at age 1	20 mGy to the RBM	Leukaemia incidence up to age 30	5	0 to 20
Occupational external exposure, age 30–45	200 mGy to the RBM	Leukaemia mortality up to age 60 excluding CLL	5	1 to 10
	100 mGy to the colon	All solid cancer mortality up to age 60	11	2 to 20
^{131}I-internal exposure at age 10	500 mGy to the thyroid	Thyroid cancer incidence up to age 30	8	2 to 20

123. Rivkind et al. *Female breast cancer risk in Bryansk Oblast, Russia, following prolonged low dose rate exposure to radiation from the Chernobyl power station accident*. INT J EPIDEMIOL. 2020 Apr 1;49(2):448-456. doi: 10.1093/ije/dyz214. PMID: 31628796; PMCID: PMC7266559,*available at* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2938757/.
124. U.N. Scientific Committee on the Effects of Atomic Radiation; Sources, Effects and Risks of Ionizing Radiation UNSCEAR 2019 Rep. to the General Assembly, Scientific Annexes A and B, ¶544(i), U.N. Doc A/74/46; GAOR, 74th Sess., Supp No. 46 (Dec. 2020) at 165.
125. Ibid ¶ 669 at 169.

The data shows a link between occupational exposure and leukemia and cancer mortality, a link between childhood ^{131}I consumption and thyroid cancer, and that infants are sensitive to low doses of radiation.

Regarding circulatory disease, the atomic survivor studies indicated the "best estimate of the cumulative excess deaths due to exposure to 1.5 Gy at age 30, and followed up to age 60 might be 5.8 (95% CI: 0.4, 12) and 11 (95% CI: 1.9, 21) deaths per 10,000 from cerebrovascular disease and heart disease, respectively."[126] More study is needed of the impact of radiation on circulatory disease. While "an increasing number of epidemiological results have been reported on radiation-associated circulatory diseases in the past decade, the evidence on potential effects is largely inconsistent and inconclusive, in particular at low to moderate doses."[127] Furthermore, the biological mechanisms behind radiation's effect on the circulatory system are unclear.[128]

These numbers (except childhood leukemia) reference mortality, rather than morbidity. More data on disease incidence is one of the 'research needs' identified at the close of the report, along with data on other exposure sources and age at dose, and more focused assessment on specific types of cancer. [129] According to the U.N. Scientific Committee on the Effects of Atomic Radiation,

> "Although much is known about radiation risks, considerable uncertainty remains regarding their quantification. In order to reduce that uncertainty, it is important to improve and continue epidemiological studies of health effects from exposures to ionizing radiation and to develop methods to quantify and combine the various sources of uncertainties."[130]

Nuclear fusion, more powerful than fission, has the potential to create more devastating and long-lasting effects, as experience from the Pacific Islands shows. The United States bombarded the Pacific Proving Grounds with test bombs for over a decade. In 1954, the U.S. tested a hydrogen bomb in the Pacific, distributing fallout over the Marshall Islands that continues to plague the people living there.[131] Babies continue to be born with mutations better suited to a Cronenberg film: 'jellyfish babies' with no bones and transparent skin, through which their beating hearts can be seen for their whole life, which lasts a mere few days.[132] In the words of a girl from Rongelap:

> …many of my friends keep quiet about the strange births that they have had. In privacy they give birth, not to children as we like to think of them, but to things we could only describe as `octopuses', `apples', `turtles', and other things in our experience. We do not have Marshallese words for these kinds of babies, because they were never born before the radiation came.[133]

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126. *Id.* ¶ 557 at 176.
127. *Id.* ¶550 and 166
128. *Id*.
129. *Id*. Ibid ¶ 535 at 171
130. *Id.* ¶55(i) at 14
131. John Scales Avery, *Hiroshima and Nagasaki Day Memorial*, NUCLEAR AGE PEACE FOUNDATION (Aug. 12, 2011), https://www.wagingpeace.org/hiroshima-and-nagasaki-day-memorial/.
132. *Id*.
133. *Id.*

As the U.S. Department of Energy considers building fusion power plants, the NRC should consider the impact of these more catastrophic nuclear accidents. A fusion future could mean exponentially more liability that, if the private sector becomes involved, Price-Anderson would also be obligated to cover.

LESSONS FROM THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION MELTDOWNS

The three meltdowns at the Fukushima Daiichi Nuclear Power Station in Japan in 2011 provide an opportunity to examine the health costs of the worst nuclear disaster since Chernobyl. Now that nearly a decade has passed, some of the effects have become clearer.

The effects of the Fukushima Daiichi meltdowns differ from those of the Chernobyl meltdown in several important respects. As the Fukushima reactors were located on the Pacific Ocean, 80% of the release ended up in the water, minimizing the dose to humans. [134] This also means deposit densities were lower beyond the evacuation area.[135] Transparency and science helped people avoid the worst of the exposure: Precautionary evacuation, warnings about foodstuffs (especially milk) and the restrictions on radionuclide concentrations on food marketed for consumption all helped to lower community exposure.[136] On the other hand, the average annual effective dose of radiation to the Japanese population is already 2.2mSv,[137] so the control populations in the studies may already have had inconsistent radiation exposures.

The effects of radiation to humans have traditionally been classified into 2 categories: deterministic effects, which occur shortly after a high dose of exposure delivered over a short period of time; and stochastic effects, which "manifest as an increased incidence of disease in a population," with effects tending to increase with increasing doses.[138] In studying stochastic effects, "it is not possible to distinguish by observation or testing whether or not the disease of a specific patient has been caused by the radiation exposure."[139] Thus, results appear in terms like "no discernible increase," which is not the same as finding an absence of risk, or ruling out irradiation as a cause.[140] UNSCEAR specifically states this measurement is not intended to disregard the suffering associated with such cases if they do occur.[141]

The Scientific Committee studied the effects of radiation in employees of the Tokyo Electric Power Company. One hundred sixty eight workers (including contractors) received doses of 100 to 250 mSv, Six workers received effective doses over 250mSv, and one worker received a dose of 679 mSv.[142] One thousand seven hundred and fifty seven workers received

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134. U.N. Scientific Committee on the Effects of Atomic Radiation; Sources, Effects and Risks of Ionizing Radiation UNSCEAR 2020 Report, Scientific Annex B: Levels and effects of radiation exposure due to the accident at the Fukushima Daiichi Nuclear Power Station: implications of information published since the UNSCEAR 2013 Report, ¶ B1. (a) and (c), (Advance Copy Annex B only), at 191, https://www.unscear.org/unscear/en/events/ffup2-launch-2021.html.
135. *Id* ¶ B1(c) at 191.
136. *Id.*
137. *Id* FN 20 at 51. MiliSievert is a measurement of low sustained radiation exposure. One Sievert is comparable to one gray.
138. *Id* ¶211 at 85-6.
139. *Id.*
140. *Id* ¶212 at 86.
141. *Id.*
142. *Id* ¶191 at 79.

absorbed ^{131}I doses to their thyroids greater than 100mGy, with 13 receiving 2Gy or more – some up to 32Gy.[143] Workers with the highest measured thyroid doses of ^{131}I from inhalation

> "…were in charge of operations at places with high radiation levels during the early phase of the accident, such as the main control rooms of the reactors, outside near the damaged reactor buildings. Some of the workers were not provided with masks having charcoal filters at the beginning and had to eat and drink at the main control rooms when air with high concentrations of radioiodine entered from outside."[144]

UNSCEAR found that "The major factor potentially affecting the reliability of external exposure assessments had been the sharing of electronic personal dosimeters during March 2011."[145] Shorter-lived isotopes such as ^{132}Te, ^{132} I, ^{133}I, and ^{136}Cs were not properly detected as radiation monitoring of Fukushima workers did not begin until 22 March.[146] The Nuclear Emergency Workers Study continues to evaluate 20,000 workers exposed in the accident for adverse health effects.[147]

By the end of 2018, the Japanese Government had awarded compensation to six nuclear power station workers for cancer: three have leukemia, two have thyroid cancer, and one has lung cancer.[148] Legal imputation is based on levels already set by the Japanese government, rather than determined by causal effect.[149] For leukemia, worker compensation is awarded for doses of 5mSv "times the number of years between (first) exposure and diagnosis of the malignancy."[150] (There is a similar compensation scheme for lympho-haematopoietic malignancies which has applied to 16 Fukushima workers.[151]) For solid cancers, the dose must be at least 100 mSv, diagnosis of the malignancy must occur with 5 years, and radiation must be the only aetiology.[152] In the United States, treatment for Leukemia with Idhifa can cost $336,000 per year.[153] For 19 cases of leukemia, that would amount to over 6 million annually in compensation for medical expenses alone.

Though the general Japanese public appears to be safe from radiation's effects at present, its concentration in the environment may cause health problems in the future. "The estimated average effective doses over the 10-year-exposure period and the average effective doses up to age 80 years are larger by factors of up to 2.5 and 4, respectively, than those received in the first year."[154] If people who live near the meltdown site develop cancer 10 or 20 years from now, who will compensate them?

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143. *Id* ¶193-195 at 80-81.
144. *Id* ¶ 201 at 83.
145. *Id* ¶188 at78.
146. *Id* ¶198 at 82.
147. *Id* ¶194 at 80.
148. Id ¶ 242 at 97.
149. *Id* FN 42 at 97.
150. *Id.*
151. *Id.*
152. *Id.*
153. Lauren Chase, *The 20 Most Expensive Prescription Drugs in the U.S.A.*, GOODRX, Feb. 18, 2021, https://www.goodrx.com/blog/20-most-expensive-drugs-in-the-usa/.
154. U.N. Scientific Committee on the Effects of Atomic Radiation; Sources, Effects and Risks of Ionizing Radiation UNSCEAR 2020 Report, Scientific Annex B, *supra* note 134 ¶ A116 at 166.

Human health effects don't end at radiation doses. Over 50 hospitalized and 100 elderly people died shortly after evacuation, possibly because of it.[155] Nuclear accidents of this magnitude, UNSCEAR noted, tend to lead to "distress and anxiety from, among other things, disruption of life, loss of homes and livelihoods, and social stigma, which can have major impacts on psychological and social well-being."[156]

COSTS OF FUKUSHIMA

To date, the meltdowns at Fukushima Daiichi have created over 2.6 million tonnes of radioactive waste.[157] Twenty two million cubic meters of soil have been removed.[158] Some of the waste has been incinerated, releasing radiation into the atmosphere; but most of it has yet to be dealt with.[159] Sitting in temporary storage, it remains an additional liability, subject to the whims of the weather. Will it be moved or decontaminated before the next extreme weather event occurs?

"We're still just very near the starting line" in cleaning up from the three core meltdowns and explosions, according to Fukushima prefecture Governot Masao Uchibori in 2021.[160] When the 2011 earthquake cut electricity to the plant, it was switched to emergency generators, which became flooded by water from the tsunami 50 minutes later. Without electricity to power the pumps that circulated cooling water around the reactor cores, they overheated and melted, blowing out roofs, and releasing radioactive steam and debris.[161] "We do not yet have an accurate grasp of what has happened to the molten fuel," according to Uchibori.[162] TEPCO believes some is still in the reactor cores, some burned through and landed on the concrete base, and some may dropped to the bottom of reactor pressure vessels (which surround the cores).[163] A remote mechanical arm will be tested in 2022, with the aim of gathering small amounts of fuel debris from unit 2.[164]

Without a clear understanding of the contents of the reactors, or a proven path to remove the debris, costs cannot be estimated with any amount of certainty. But 900 tons of melted fuel sitting in place isn't a solution either.[165] If the constant stream of water cooling the molten fuel is interrupted (perhaps due to another natural disaster), these exposed fuel rods could overheat, causing a meltdown worse than the original.[166] This irradiated water is a major problem in itself. "Over the past decade, more than 1.24 million tons of tritium-contaminated water have accumulated, filling more than 1000 tanks that occupy nearly every available nook on the

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155. *Id* ¶213 at 86
156. *Id.*
157. *Id* ¶123 at 50.
158. *Id.*
159. *Id.*
160. Dennis Normille, *Why Cleaning Up Fukushima's Damaged Reactors Will Take Another 30 Years*, SCIENCE, Mar. 4, 2020, https://www.sciencemag.org/news/2021/03/why-cleaning-fukushima-s-damaged-reactors-will-take-another-30-years.
161. *Id.*
162. *Id.*
163. *Id.*
164. *Id.*
165. Mari Yamaguchi, *How Dangerous is the Fukushima Nuke Plant Today?*, ASSOCIATED PRESS, Mar. 11, 2021, https://apnews.com/article/world-news-japan-tsunamis-5a5a70d852d2290d527123d3ec300c57.
166. *Id.*

Fukushima Daiichi campus."[167] Cobalt, ruthenium, strontium, and plutonium isotope traces in the water are concerning, as is the lack of space for more: storage room will run out by summer 2022.[168]

The Japan Center for Economic Research has attempted to evaluate cleanup costs of the Fukushima Nuclear Accident, revising its top estimate in March 2019 upwards to 80 trillion yen.[169] In today's dollars, this figure is over $729 billion.[170] Continuing to cool the fuel until 2030 would contaminate another 800,000 tons of water, bringing the total to 2 million tons.[171] It would take 40 trillion yen to remove the strontium and tritium from this water.[172] The cheapest option compared (35 trillion yen) was to postpone decommissioning, manage the debris by confining it, and release tritium water into the ocean (making it an international problem).[173] Additional costs considered included compensating landowners in a 10 km radius if decontamination is not possible (1.1 trillion yen or $10 billion), [174] and compensating the fishing industry if water is released into the ocean.[175]

Who is going to pay? "It is clear from both economic and technological perspective," concludes JCER, "that TEPCO alone will not be able to complete the decommissioning of the Fukushima Daiichi power plant."[176] Though costs continue to increase, there has been a "lack of explanations regarding the public financial burden, decommissioning cost, and compensation costs."[177] The report calls for higher transparency and international funds, reminding the United States that the Federation of Electric Power Companies of Japan contributed $18 million after the Three Mile Island meltdown.[178] (It also calls for a revision of the Atomic Energy Damage Compensation law, which regulates the unlimited liability of Japan's power companies).[179] The economic fallout of the Fukushima Daiichi meltdowns demonstrates that even in the case of a modern nuclear meltdown that spared the population from discernible health effects, costs would far outstrip the assumed amounts baked into the Price Anderson Act.

At the time of JCER's report, even though eight years had passed, 40,000 people remained evacuated, "there is no end in sight for the depopulation of Fukushima prefecture and it seems that the reconstruction is not even at the halfway mark."[180] Among its conclusions were that "Nuclear power generation cannot continue unless there is consensus about [spent fuel, plutonium] and radioactive waste. From the commercial viewpoint, there is no margin for investing large amounts of money into the research and development of fast reactors and nuclear

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167. Normille, *Why Cleaning Up…, supra* note 160
168. *Id.*
169. *Follow up Report of public Financial Burden of the Fukushima Nuclear Accident,* JAPAN CENTER FOR ECONOMIC RESEARCH, March 7, 2019 at 1.
170. *Id*
171. *Id.*
172. *Id.*
173. *Id* at 2.
174. *Id.*
175. *Id* at 4.
176. *Id* at 6.
177. *Id* at 5.
178. *Id* and FN at 5.
179. *Id* at 7.
180. *Id*

fuel cycles."[181] The report speaks plainly: "Insisting on the retention of nuclear power generation on economic terms shows a failure in logic."[182]

BUT IT'S ALREADY IN MY BACKYARD: RISKS AND BURDENS FACED BY COMMUNITIES NEAR AGING NUCLEAR REACTORS

Continued use of aging nuclear reactors shifts a disproportionate risk onto people located near energy facilities. Three of Illinois' nuclear plants made the "top twenty-five" in the Daily Beast's list of the fifty most vulnerable, based on safety assessments, risk of natural disaster, and size of nearby population.[183] Two-reactor Dresden in Morris was fourth on the list, with a bottom-third safety ranking, a risk of tornadoes, and almost eight million people living within 50 miles.[184] The two-reactor Braidwood facility in Braceville was twelfth with the same issues but slightly fewer tornadoes and fewer people at 6.8 million.[185] The Lasalle County plant in Marsailles came in at number twenty-five, with a bottom third safety rating and two million people living within 50 miles.[186]

In 2005, the Illinois EPA uncovered eight different tritium releases at Exelon's Braidwood plant dating back to 1996, including releases in excess of 20,000 pCi/L that contaminated groundwater.[187] A 2011 Associated Press report, using NRC data going back to 2000, found tritium contamination thirty-six times the drinking water limit in 2010 due to an accidental storage tank release at the LaSalle site, and 375 times the limit from an underground pipe leak at the Quad Cities plant in 2008.[188] Over 650,000 Illinoisans get their drinking water from within fifty miles of an active nuclear power plant.[189] This adds up to substantial health and environmental risks.

The Illinois Environmental Management Agency (IEMA), which measures radiation in water around plants, notes a margin of error of about 100 pi/L,[190] but radiation levels still might be underreported. The IEMA uses Sangchris Lake, a cooling lake for a coal power plant, to establish background radiation levels, even though coal ash is also radioactive.[191] A 1978 paper from Oak Ridge Laboratories calculated that people living near coal plants were exposed to the

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181 *Id.*
182 *Id* at 5.
183. Clark Merrefield et al., *supra* note 2
184. *Id.*
185. *Id.*
186. *Id.*
187. Press Release, Illinois Att'y Gen. Lisa Madigan, Madigan, Glasgow File Suit for Radioactive Leaks at Braidwood Nuclear Plant: Leaks of Tritium-Laced Wastewater Date to 1996 (Mar. 16, 2006), http://www.illinoisattorneygeneral.gov/pressroom/2006_03/20060316.html.
188. Donn, *supra* note 110.
189. Press Release, Ill. Pub. Interest Research Grp., Nuclear Plants Pose Risks to Drinking Water for Illinois (Jan. 24, 2012), http://www.illinoispirg.org/news/ilp/nuclear-power-plants-pose-risks-drinking-water-illinois.
190. ILL. EMERGENCY MGMT. AGENCY, ENVIRONMENTAL MONITORING PROGRAM FOR NUCLEAR POWER STATIONS REPORT FOR CALENDAR YEAR 2014, at 6 (Aug. 2015), https://www.illinois.gov/iema/NRS/ Documents/NPSReport2014.pdf.
191. *Id* at 31.

same or more radiation than those near nuclear plants.[192] Without an accurate control group, even the reported numbers could be significantly understated.

It is hard to say how likely it is for another nuclear catastrophe to happen with only fifty years of experience with this source of fuel. However, there are some numbers available from which to generate a rough probability. Humanity has a collective 16,000 reactor-years of experience with nuclear energy (a cumulative calculation that adds the amount of years each reactor has been in operation), during which three major accidents have occurred at commercial nuclear reactors: Chernobyl, Three Mile Island, and Fukushima; according to the World Nuclear Association (a pro-industry nonprofit).[193] The Three Mile Island meltdown was confined completely to the plant, meaning only two accidents at commercial reactors caused serious radiological releases. One event every 5,333 reactor-years comes out to a roughly 0.2% annual risk of incident for an 11-reactor state like Illinois.

Terrorism is an additional concern. Acquiring material from uranium mines, attacking a nuclear reactor, assaulting spent fuel storage, intercepting materials in transit, manipulating a nuclear worker, and making dirty bombs with radioactive tailings from processing plants are all ways that bad actors can acquire nuclear materials. According to the International Policy Institute for Counter Terrorism, between 1970 and 1999 there were 167 acts of terrorism involving a nuclear target.[194] From January 2003 to December 2012, the International Atomic Energy Agency's Incident and Trafficking Database recorded 419 incidents of criminal unauthorized possession of nuclear materials from any source.[195] Although nuclear fuel is not nearly as dangerous as weapons, the concentrated power of dangerous materials tends to draw bad actors.[196] Since 9/11, the NRC has instituted emergency preparedness standards that specifically address terrorism and cybercrime, and it is evaluating employees' safety culture at specific plants.[197] However, there is no way to completely guarantee security against all possible threats.

The choice of increased nuclear dependence shifts an increased amount of risk onto those communities located near reactors. Meanwhile, states are limited in the measures they can take to regulate nuclear energy due to the doctrine of federal pre-emption. As a resident of Illinois, I hereby object to the excess risk that the liability indemnification provision of the Price Anderson act forces myself, my community, and my loved ones to shoulder.

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192. Mara Hvistendahl, *Coal Ash Is More Radioactive than Nuclear Waste*, SCI. AM. (Dec. 13, 2007), http://www.scientificamerican.com/article/coal-ash-is-more-radioactive-than-nuclear-waste/.
193. *Safety of Nuclear Power Reactors*, WORLD NUCLEAR ASS'N (May 2016), http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx. The Mayak (Kyshtym) disaster is not included because it was a government owned nuclear reactor.
194. SOVACOOL ET AL., *supra* note 27, at 186.
195. *Id.* at 167.
196. *See id.* at 165–67, 185–88 (describing lists of civilians found in possession of nuclear materials and terrorist attacks involving them); *see also N.Y. Klansman Gets 30 Years in Prison for Plot vs Muslims, Obama*, REUTERS (Dec. 19, 2016, 2:42 PM), http://www.reuters.com/article/us-new-york-deathray-idUSKBN14812B (describing the first conviction under a 2004 federal law prohibiting dirty bombs).
197. GUTIERREZ & POLONSKY, *supra* note 47, at 83.

THE PRICE ANDERSON ACT IS UNABLE TO DO WHAT IT PURPORTS TO AND THUS SENDS A PERVERSE SIGNAL TO INVESTORS AND THE PUBLIC

The purpose of energy regulation is to mimic a competitive marketplace. Utilities are entitled to make a profit –to ensure financial integrity of the enterprise, compensate investors for risk, and attract capital.[198] This capital attraction function is a major purpose of energy regulation; without a return on investment, there would be no incentive for utilities to construct large power generation facilities. But the reason we don't have [more] government-run utilities is, theoretically, to shift the investment risk onto the private sector. This is so the public won't be liable for bad energy investments. The Price-Anderson act turns this logic on its head, ensuring the nuclear industry that it won't be liable for catastrophic harm to the public. Energy is supposed to benefit the populace, not the other way around.

Because it does not do what it purports to, the Price Anderson Act sends a perverse signal to investors, that nuclear energy is a viable option, when it is not. Although a few investors may profit in the short term, in the long term they are wagering our environment and the health of our communities. The Price Anderson Act should be modified in two specific ways.

The following sentence should be stricken from 42 U.S.C § 2210 (b)(1): " And provided further, That the amount which may be charged a licensee following any nuclear incident shall not exceed the licensee's pro rata share of the aggregate public liability claims and costs (excluding legal costs subject to subsection (o)(1)(D), payment of which has not been authorized under such subsection) arising out of the nuclear incident." Additionally, Section (b)(4)(A) should provide that, in the event that funds are unavailable, directors and investors in the polluting company should be held personally liable, to the limit that they have profited from the company.

The NRC should ensure that nuclear companies compensate members of the public appropriately for effects due to releases of nuclear material. The Price Anderson Act says that a nuclear incident is "unlikely", but the reality has changed. Time has passed. The parts that used to be new are aging, rusting, corroding. Furthermore, it is naïve to assume all incidents are accidents. As facilities age, proper management becomes much more important, and as such it is imperative that nuclear energy companies be held liable for their mistakes, negligence, deferred maintenance, and even sabotage (if no safeguards or employee monitoring programs were in place). While compensation is important to the public, so is responsibility. Nuclear energy generators should be held strictly liable for all of contamination they produce, and if additional indemnity is needed, that money should come from the profits of directors and shareholders – not the public at large.

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198. JOSEPH P. TOMAIN & RICHARD D. CUDAHY, ENERGY LAW IN A NUTSHELL 130 (2004). See also Fed. Power Comm'n v. Hope Nat. Gas Co., 320 U.S. 591, 603, 605 (1944).