# The Effect of the Fukushima Daiichi Disaster on the U.S. Nuclear Energy Community

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## INTRODUCTION

On August 1, 1946, President Truman signed the Atomic Energy Act (AEA) of 1946 and thereby enacted legislation that transferred dominion over the nation's nuclear energy program from the military and the executive branch to an administrative body controlled by both Congress and the President.[1] The purpose of the AEA of 1946 was "[f]or the development and control of atomic energy,"[2] a seemingly unified mandate that generated conflict repeatedly over the past seven decades. The larger goal of the U.S. nuclear energy program was to create a modern energy source that would power the

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[1] Atomic Energy Act of 1946, Pub. L. No. 79-585, 60 Stat. 755.

[2] *Id.*

greatest nation on the Earth into the future.[3] While the utopian image of a nuclear-powered society that President Eisenhower dreamed of may have never fully materialized, it is undisputable that nuclear energy plays an important role in the U.S. energy portfolio.[4]

The continued importance of nuclear energy to the U.S. energy market makes the recent events at Fukushima all the more significant. As such, I will use Part I of this article to describe the three phases the U.S. nuclear energy community went through in its evolution from a military weapons program to a substantial and controversial part of the U.S. energy portfolio. In light of this background, in Part II, I will then introduce and give an overview of the Great East Japan Earthquake and its effect on the Fukushima Daiichi plant. Part III includes the reactions of various nuclear energy stakeholders, with a focus on the domestic response to this disaster. In Part III, I will also analyze the existing nuclear community and suggest areas in which the U.S. nuclear community can learn from the events at Fukushima. In Part IV, I conclude by drawing key lessons from Fukushima and stressing the importance of considering low-risk/high-cost events in nuclear energy risk management strategies. The most important lesson, therein, being that the community must learn to accept and benefit from stakeholder input, thereby encompassing the information that this input makes available to the community.

## I. THE HISTORY OF NUCLEAR ENERGY IN THE U.S.

To properly understand the current domestic nuclear community, one must have an understanding of the historical context of domestic nuclear energy and the key factors influencing the major domestic nuclear stakeholders. This is not to say that this article intends to provide comprehensive coverage of the history of nuclear energy, of the

[3] ROBERT J. DUFFY, NUCLEAR POLITICS IN AMERICA: A HISTORY AND THEORY OF GOVERNMENT REGULATION 32 (1997).
[4] *Nuclear & Uranium*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/totalenergy/data/monthly/pdf/sec8_3.pdf (last visited Oct. 12, 2015) (calculating nuclear energy as accounting for twenty percent of domestic primary energy production).

politics of nuclear energy,[5] or of all the factors influencing the nuclear industry.[6] Rather, this article seeks to analyze how the domestic nuclear community can best plan for low-risk/high cost events. This analysis must be set within a proper historical context, as history defined the current planning processes.

A. Early 1940s–1946: Atomic Weaponization

The genesis of nuclear energy traces to the attempts, and eventual success, to harness the power of the atom for warfare by the U.S.[7] Of particular note is the Manhattan Project, a joint effort between "industry, the military, and tens of thousands of ordinary Americans working at sites across the country to translate original scientific discoveries into an entirely new kind of weapon."[8] This massive national security operation involved 130,000 workers and cost $2.2 billion.[9] The initial stages of harnessing nuclear energy trace back to this private-military partnership. While there was

[5] *See generally* DUFFY (Duffy's book provides the furthest spanning coverage and relies in part on Walker and Hewlett's work when discussing those particular periods). The two following books are excellent examples of their work: SAMUEL J. WALKER, CONTAINING THE ATOM: NUCLEAR REGULATION IN A CHANGING ENVIRONMENT 1963-1971 (1992) and RICHARD G. HEWLETT, ATOMS FOR PEACE AND WAR, 1953-1961: EISENHOWER AND THE ATOMIC ENERGY COMMISSION (1989).

[6] These factors are numerous. This paper will not discuss the very serious and long-term issue of nuclear waste disposal. For a concise discussion of the nuclear waste problem, *see* Karl S. Coplan, *The Intercivilizational Inequities of Nuclear Power Weighed Against the Intergenerational Inequities of Carbon Based Energy*, 17 FORDHAM ENVTL. L. REV. 227, 233-44 (2006). Additionally, this article will largely avoid the economic motivations that influence the industry, including the price of other energy sources and state utility rate-setting. For a thorough modeling of the cost of new nuclear construction in light of such factors, *see* Bernell K. Stone, *Using Fair Return Prices to Assess the Value and Cost of Financial Guarantees for New Nuclear Power Plants*, 6 BYU INT'L L. & MGMT. REV. 83 (2009). Finally, this article will not comment on the environmental justice issues that accompany the siting and regulation of the extraction of nuclear fuel, nuclear reactors, and waste disposal facilities. Although long under-publicized, these issues pose very important impacts. *Cf.* Omar Saleem, *Overcoming Environmental Discrimination: The Need for a Disparate Impact Test and Improved Notice Requirements in Facility Siting Decisions*, 19 COLUM. J. ENVTL. L. 211, 215 (1994) ("The CRJ report concluded: 'Race proved to be the most significant among variables tested in association with the location of commercial hazardous waste facilities. This represented a consistent national pattern.' . . . Such facilities are disproportionately located in low-income racial minority communities.") (quoting UNITED CHURCH OF CHRIST COMM'N FOR RACIAL JUSTICE, TOXIC WASTES AND RACE IN THE UNITED STATES: A NATIONAL REPORT ON THE RACIAL AND SOCIO-ECONOMIC CHARACTERISTICS OF COMMUNITIES WITH HAZARDOUS WASTE SITES xiii (1987)).

[7] Duffy, *supra* note 3, at 22.

[8] *Manhattan Project*, U.S. DEP'T OF ENERGY, http://energy.gov/management/manhattan-project (last visited Oct. 12, 2015).

[9] *Id.*

some debate as to the propriety of using an atomic weapon, the two bombs dropped on Japan were undoubtedly effective and brought about the Japanese surrender on August 14, 1945.[10] From this, the U.S. public roundly supported the prospect of ultimately deriving electricity from the same research that produced the war-ending bombs.[11]

### B. 1946-Mid-1960s: Moving From Weaponization To Commercialization

As the Manhattan Project succeeded in producing two nuclear weapons, the Project also succeeded in generating ideas that would be the foundation for the current nuclear energy community.[12] To nurture these fledgling ideas, Congress passed the Atomic Energy Act of 1946 (AEA).[13] This Act established the administrative and regulatory framework that oversaw the founding of the nuclear energy industry. The original AEA created a federal atomic monopoly, or rather codified the existing monopoly, and divided power over this technology between three groups. First, the Act created the Atomic Energy Commission (AEC), headed by five Presidential nominees, subject to Senate confirmation.[14] Congress tasked the AEC with the job of developing and regulating the fledgling nuclear industry, so as to benefit the public welfare while retaining control over related scientific and technical information.[15] Second, the Act established a Joint Committee on Atomic Energy (JCAE), staffed by eighteen members of Congress, to "make continuing studies of the activities of the [AEC] and of problems relating to the development, use, and control of atomic energy."[16] Finally, the AEA created a General Advisory Committee to advise the AEC on technical matters.[17]

There are several important elements of this original nuclear framework that influenced the development of nuclear energy. First, this regulatory framework did not

[10] TERRENCE R. FEHNER & F.G. GOSLING, U.S. DEP'T OF ENERGY, THE MANHATTAN PROJECT 6-7 (2012), *available at* http://energy.gov/sites/prod/files/The%20Manhattan%20Project.pdf.
[11] Duffy, *supra* note 3 at 22.
[12] *Id.*
[13] *See* Atomic Energy Act of 1946, Pub. L. No. 79-585, 60 Stat. 755.
[14] *Id.* § 2(a).
[15] *Id.* § 1(b).
[16] *Id.* § 15.
[17] *Id.* § 2(a)(4)(b).

separate electricity-producing research from military research. This is somewhat understandable, as both lines of research stemmed from the Manhattan Project with each based on the same scientific principles. On the other hand, the two lines of research individually aimed at very different endpoints, thereby making development and regulation by a unified body a difficult task. Indeed, even in 1961, weapons and military-based applications were the objects of two-thirds of the AEC's reactor development budget.[18] The contrast between these two lines of development would lead to inefficiencies and conflict.

The second key element of this framework was that there were relatively few stakeholders with any real power over nuclear research. This had two large implications: (1) that the public had almost no influence on, or exposure to, developments within the domestic nuclear community (given that the AEC was relatively independent from the executive branch,[19] it only had to answer to the JCAE); and (2) that this small group of nuclear actors, many of whom originated from the Manhattan Project, had a unified vision of the role of nuclear energy in America's future.[20] As there was little in the way of input or control by any person not in the AEC or the JCAE, these actors were able to efficiently work toward their self-selected goals.[21]

The third key element was the role national security concerns played in the disclosure of information generated by the AEC. Given the AEC's joint dominion over both nuclear weapons and energy production, the AEC and JCAE were able to shield almost all substantive information about their work under the classification of "restricted data."[22] This shield reinforced and furthered the efficiency of the AEC/JCAE nuclear policy monopoly. Indeed, within this tightly controlled environment, the U.S. incubated the fledgling nuclear power industry.

However, as the world polarized due to the Cold War, the AEC's joint control of

[18] Duffy, *supra* note 3 at 27.
[19] *See id.*
[20] *Id.* at 30.
[21] *See id.*
[22] *Id.* at 24.

both weapons-oriented and energy production-oriented nuclear power began to taint the image of nuclear energy production. Not surprisingly, the fears of nuclear war tainted the public image of nuclear energy production. In response, President Dwight D. Eisenhower spoke to the United Nations General Assembly on December 8, 1953.[23] In this address, commonly referred to as the "Atoms for Peace" address, President Eisenhower identified the U.S. as a promoter of the peaceful and industrious use of nuclear energy.[24] Among other motivations, President Eisenhower clearly wished to separate the destructive images of Hiroshima and Nagasaki from the constructive possibilities nuclear energy offered, especially given that President of the U.S. was himself a five-star general in the U.S. Army during World War II. With this context, President Eisenhower boldly pronounced that

> my country's purpose is to help us move out of the dark chamber of horrors into the light, to find a way by which minds of men, the hopes of men, the souls of men everywhere, can move forward towards peace and happiness and well-being. . . . Who can doubt that, if the entire body of the world's scientists and engineers had adequate amounts of fissionable materials with which to test and develop their ideas, this capability would rapidly be transformed into universal, efficient and economic usage?[25]

However, President Eisenhower's utopian vision of a nuclear-powered world faced significant problems domestically, namely cost.

Realizing this utopian image would require private capital, which was not authorized under the AEA of 1946, Congress proceeded to amend this framework by adopting the Atomic Energy Act of 1954.[26] This new framework provided a licensing mechanism where the AEC could allow private entities to possess and control nuclear

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[23] President Dwight D. Eisenhower, United States, Address to the 470th Plenary Meeting of the United Nations General Assembly (Dec. 8, 1953) (commonly referred to as President Eisenhower's "Atoms for Peace" address), *available at* http://www.eisenhower.archives.gov/research/online_documents/atoms_for_peace/Binder13.pdf. This is not to say that the only reason President Eisenhower spoke to the UN General Assembly was to mend nuclear energy's public image. Rather, this address was a part of President Eisenhower's larger Cold War nuclear strategy. For a further discussion of this strategy, *see generally* John A. Hall, *Atoms for Peace, or War*, 43 FOREIGN AFF. 602 (1965).

[24] *See* Eisenhower, *supra* note 23.

[25] Eisenhower, *supra* note 23.

[26] Atomic Energy Act of 1954, Pub. L. No. 83-703, 68 Stat. 919 (1954).

material.[27] As a part of this licensing program, the AEC would have to make certain findings regarding the applicant.[28] The AEC would have to find that the applicant would beneficially use the nuclear material, had proper safety precautions in place, and would release all technical data to the AEC upon request.[29] Subject to renewal, each license had a maximum of a forty-year lifespan.[30]

This licensing framework would allow private industry to enter the nuclear energy production community and would thus accelerate the realization of nuclear energy's use in the U.S. electricity grid. However, the AEA of 1954 did not amend the AEC's seemingly conflicting goals of both promoting nuclear energy and regulating that same industry. The declarations and findings of the AEA of 1954 focused on the peaceful use of nuclear energy and its continuing role in national defense,[31] but failed to recognize problems inherent to this mandate. Furthermore, it is important to note that despite President Eisenhower's concern with the "minds, the hopes, and the souls" of men everywhere, the AEA of 1954 granted the President power to order any private license holder to deliver fissionable materials to the Department of Defense "in the interest of national defense."[32] While the AEA of 1954 was seemingly a step towards a nuclear-powered utopia, a tension between the constructive power and destructive power of nuclear energy remained within the domestic nuclear framework.

To further incentivize private industry to enter the nuclear energy community, Congress once again amended the licensing framework to limit license holder's liability in the 1957 Price-Anderson Act.[33] This amendment applied to all "nuclear incidents"[34]

[27] *Id.* ch. 10, 68 Stat. at 936-37.
[28] *Id.* § 103, 68 Stat. at 936-37.
[29] *Id.*
[30] *Id.* § 103(c), 68 Stat. at 937.
[31] *Id.* ch. 1, 68 Stat. at 921-22.
[32] *Id.* § 91, 68 Stat. at 936.
[33] Price-Anderson Act, Pub. L. No. 85-256, 71 Stat. 576 (1957).
[34] *Id.* § 3(o), 71 Stat. at 576.

> The term "nuclear incident" means any occurrence within the United States causing bodily injury, sickness, disease, or death, or loss of or damage to property, or for loss of use of property, arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material.

requiring license holders to obtain liability insurance, with limited aggregate liability coverage, in exchange for the possibility that the federal government may satisfy some of the outstanding claims.[35] In short, the 1957 amendment reflected the U.S.'s desire to involve private industry in nuclear energy and further incentivized such involvement.

### C. Mid-1960s–1975: Rise Of Commercial Nuclear Energy

Subsequent to opening the nuclear energy community to private industry, businesses hesitated to enter this uncharted territory. While there was an ever-increasing demand for electricity, uncertainties of nuclear reactor construction and operation costs initially slowed private participation. The following chart details the growth of the nuclear industry over the relevant years and highlights the slow entry of private businesses into the industry.[36]

Table 1: Reactor Orders and Megawatt Capacity by Years

| **Years** | **Reactor Orders** | **Total Capacity (Megawatt Electrical)** |
|---|---|---|
| 1955-59 | 5 | 777 |
| 1960-64 | 7 | 3,650 |
| 1965-69 | 81 | 70,099 |
| 1970-74 | 142 | 157,078 |
| 1975-79 | 13 | 15,232 |

To combat this hesitation, the AEC compiled a report regarding the future of nuclear energy, titled *Civilian Nuclear Power – A Report to the President* (the "Report").[37] The Report concluded that "nuclear power promises to supply the vast

[35] Price-Anderson Act, Pub. L. No. 85-256, 71 Stat. 576 (1957).
[36] Duffy, *supra* note 3, at 52, Table 3.1. (referencing U.S. ENERGY INFO. ADMIN., COMMERCIAL NUCLEAR POWER 1991: PROSPECTS FOR THE UNITED STATES AND THE WORLD 105-110 (1991)).
[37] U.S. ATOMIC ENERGY COMM'N, CIVILIAN NUCLEAR POWER – A REPORT TO THE PRESIDENT (1962), *available at* http://energyfromthorium.com/pdf/CivilianNuclearPower.pdf.

amounts of energy that this nation will require for many generations to come."[38] Indeed, the Report can be seen as the culmination of the positive public image of nuclear energy, and the unified legislative and regulatory efforts of the previous sixteen years.[39] Not surprisingly, it called for the federal government to "take the lead in developing and demonstrating the technology in such ways that economic factors will promote industrial applications in the public interest and lead to a self-sustaining and growing nuclear power industry."[40] In pertinent part, this led to the conclusion that "[t]he Government must clearly play a role" in subsidizing nuclear energy, as "the product does not meet some hitherto unfilled need," and the industry cannot otherwise compete with existing conventional fuel sources.[41] What would later become clear was how overly optimistic the industry's and the AEC's estimates were regarding the cost of developing nuclear reactors.[42]

Given the increasing number of nuclear stakeholders and the growth of federal environmental laws, the nuclear community ceased to be as closed and efficient as it once was. Private industry broke ground for reactors throughout the country. However, as construction continued, the actual cost of building nuclear power plants far exceeded the estimates that led to the boom of reactor orders between 1965 and 1975.[43] The public also became involved in the nuclear energy community because its production resulted in thermal and radioactive pollution. It was the short-term and immediately observable effects of thermal pollution that initially motivated segments of the public to oppose nuclear energy.[44] In addition, the threat of radiation pollution was, and still is, inherent to the nuclear industry. A 1968 study funded by the AEC found that the AEC's regulations regarding air emissions from nuclear plants were too lax and presented risks of radiation

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[38] *Id.* (excerpt from introductory letter).
[39] *See* Duffy, *supra* note 3, at 45-46.
[40] U.S. ATOMIC ENERGY COMM'N, *supra* note 37, at 8.
[41] *Id.* at 27.
[42] Duffy, *supra* note 3, at 52.
[43] *Id.* at 52.
[44] *Id.* at 54-55.

pollution.[45] Three years later, Congressional hearings regarding nuclear plant emergency cooling systems exposed the downside of such a tight-knit industry-regulatory relationship, as the hearings found multiple shortcomings in the AEC's regulations and enforcement of those regulations.[46] In 1975, a group of highly regarded Manhattan Project and AEC scientists publically called for a decline in the construction of nuclear reactors pending amendment of the existing safety regulations pertaining to particular safety concerns.[47] These calls for reform, coupled with the public's new role in licensing decisions,[48] marked the death of the utopian vision of nuclear energy and signaled the need for reform within the domestic nuclear community.

### D. 1975-2005: The Slowing Of Commercial Nuclear Growth

The most recent three and a half decades have seen a stagnation of the growth of the nuclear industry. A combination of a negative public image, increased political oversight, and heightened safety demands combined to make building new nuclear plants economically unfavorable. Partly in response to the calls for reform by key nuclear stakeholders and the public, Congress passed the Energy Reorganization Act of 1974 (ERA).[49] The ERA abolished the AEC and established two new administrative bodies: the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC).[50] Congress split the responsibilities of the former AEC between these two commissions, making the ERDC responsible for the "research and development [of] the various sources of energy"[51] and the NRC responsible for the

[45] *Id.* at 60 (citing JOHN W. GOFMAN & ARTHUR W. TAMPLIN, POISONED POWER: THE CASE AGAINST NUCLEAR POWER PLANTS (1971)).
[46] *Id.* at 62.
[47] *Id.* at 66.
[48] *See* Calvert Cliffs' Coordinating Comm., Inc. v. U.S. Atomic Energy Comm'n, 449 F.2d 1109 (D.C. Cir. 1971) The then newly enacted National Environmental Policy Act of 1969 ("NEPA") instituted procedural obligations in the agency review process that bolstered public examination of and public participation in federal actions.
[49] Energy Restoration Act of 1974, Pub. L. No. 93-438, 88 Stat. 1233 (1974).
[50] *Id.* §§ 101, 201.
[51] *Id.* § 2(b).

"licensing and related regulatory functions of the [AEC]."[52] This split explicitly aimed to guarantee the "adequacy of technical and other resources necessary for the performance of each [set of responsibilities]."[53] Thus, Congress sought to move away from the tunnel-vision attendant with the AEC's sole dominion over the nuclear community, as this administrative framework failed to adequately address many of the economic and environmental problems that accompanied the growth of the nuclear industry.

Despite Congress' efforts, the domestic nuclear community was unable to reverse the deep flaws within the regulatory framework. The Three Mile Island incident exposed these flaws. On March 28, 1979, a failure in the cooling system at the Three Mile Island (TMI) nuclear plant threatened the stability of the core and resulted in a release of contaminated coolant.[54] Considered primarily a human error, the incident at TMI "caused the [NRC] to tighten and heighten its regulatory oversight" of the nuclear industry.[55] This increase in regulatory oversight seemed necessary as the NRC focused on the promotion of nuclear energy, thereby enabling deficiencies in its regulation of the industry.[56] Under the combined weight of high construction costs and necessary regulatory measures, the nuclear industry stagnated over the years following TMI and continued, more or less, to the present.

## II. THE GREAT EAST JAPAN EARTHQUAKE

More than three decades after the accident at TMI, a different type of nuclear accident occurred in Japan's Fukushima Prefecture. On March 1, 2011, a historic earthquake occurred off the northeast coast of Japan.[57] The earthquake registered a 9.0 Magnitude on the Richter Scale and generated a peak horizontal ground motion of 0.561

[52] *Id.* § 2(c).
[53] *Id.*
[54] U.S. Nuclear Regulatory Comm'n, *Backgrounder on the Three Mile Island Accident*, NRC Library, (Feb. 11, 2013), http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.
[55] *Id.*
[56] *See generally* JOHN G. KEMENY ET AL., REPORT OF THE PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE ISLAND (1979), *available at* http://www.pddoc.com/tmi2/kemeny/index.html.
[57] MARK HOLT ET AL., CONG. RESEARCH SERV., R41694, FUKUSHIMA NUCLEAR DISASTER 1 (2012).

centimeters-per-second-squared at the Fukushima Daiichi plant.[58] This ground motion speed exceeded the plant's 0.447 centimeters-per-second-squared design basis and triggered a scram of the active reactors.[59] Forty-one minutes after the earthquake, a series of seven tsunamis began to arrive at the plant, the largest of which was approximately fourteen to fifteen meters high (approximately fifty feet).[60] However, the design basis for the plant was only 5.7 meters (approximately eighteen feet). Therefore, this enormous wave exceeded the safety design by up to eight meters (approximately thirty feet).[61]

The earthquake and subsequent tsunamis caused the reactors to shut down and knocked out both the power lines, carrying external electricity, and some of the emergency diesel generators.[62] This loss of power disabled the cooling pumps and allowed the core of the reactors to overheat.[63] Overheating caused two major problems in the Mark I reactor design (the design of the reactors at Fukushima): (1) emission of airborne radiation; and (2) generation of hydrogen gas.[64] Emission of airborne radiation occurred when the overheating fuel generated enough steam so that the pools normally surrounding the spent fuel exposed the fuel to open air.[65] Some of this radiation escaped through a relief valve and possibly through later pressure-reduction ventings.[66] In addition to this radiation, hydrogen gas accumulated inside the reactor, as the steam reacted with the zirconium cladding around the fuel.[67] This hydrogen build-up was likely

[58] INST. OF NUCLEAR POWER OPERATION [INPO], SPECIAL REPORT ON THE NUCLEAR ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION 5-6 (2011).
[59] *Id.* at 6.
[60] *Id.* at 7; *Japan Nuclear: UN Says Tsunami Risk Was Underestimated*, BBC (June 1, 2011, 6:23 PM), http://www.bbc.co.uk/news/world-asia-pacific-13611797.
[61] INPO, *supra* note 58, at 7; *Japan Nuclear: UN Says Tsunami Risk Was Underestimated*, *supra* note 60.
[62] INPO, *supra* note 58, at 7; *One Year On: The Fukushima Nuclear Accident and its Aftermath*, INT'L ATOMIC ENERGY AGENCY (March 9, 2012), http://www.iaea.org/newscenter/news/2012/fukushima1yearon.html.
[63] INPO, *supra* note 58, at 9-10; *One Year On: The Fukushima Nuclear Accident and its Aftermath*, *supra* note 62.
[64] INPO, *supra* note 58, at 9-10.
[65] *Id.* at 10.
[66] *Id.* at 17, 39; *see* Matthew L. Wald, *The Nuclear Industry and Venting, Round 2*, N.Y. TIMES (July 3, 2012, 7:50 AM), http://green.blogs.nytimes.com/2012/07/03/nuclear-industry-and-venting-round-2/#more-143753.
[67] INPO, *supra* note 58, at 8-9. Cladding is a protective layer of material meant to prevent radiation from leaking into the coolant.

the cause of the explosion that occurred in one of the reactors.[68] The vented radiation and the radiation that escaped through explosion-caused structural weaknesses combined to produce the worst nuclear accident since Chernobyl, with an estimated damage total of seventy-five billion dollars.[69]

## III. THE DOMESTIC RESPONSE TO FUKUSHIMA

### A. Direct Domestic Effects

Despite the severity of the incident at Fukushima, it will likely not have any material affect directly on the U.S. A study conducted by the Congressional Research Service determined that there were four main vectors of radiation pollution worthy of study.[70] The first worry was that contaminated ocean water could carry radiation to U.S. shores, specifically because there was a direct leak from a reactor's seawater inlet point into the Pacific Ocean.[71] However, the study concluded that the amount of radioactive material released into the ocean would be so diluted that it would not have any material effect on the U.S.[72] This is not to say that there are not contamination worries in the Pacific Ocean, as Japan enacted a fishing ban "within a [two]-kilometer radius around the damaged nuclear facility."[73] Even now, the Japanese coast confines the negative implications of the second vector for radiation dispersion: fish contamination.[74]

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[68] *Id.* at 9; David Biello, *Partial Meltdowns Led to Hydrogen Explosions at Fukushima Nuclear Power Plant*, SCI. AM. (Mar. 14, 2011), *available at* http://www.scientificamerican.com/article.cfm?id=partial-meltdowns-hydrogen-explosions-at-fukushima-nuclear-power-plant.
[69] HOLT ET AL., *supra* note 57, at 1.
[70] *See* EUGENE H. BUCK & HAROLD F. UPTON, CONG. RESEARCH SERV., R41751, EFFECTS OF RADIATION FROM FUKUSHIMA DAI-ICHI ON THE U.S. MARINE ENVIRONMENT 2-7 (2012).
[71] *Id.* at 2.
[72] *Id.* at 4.
[73] *Id.* (citation omitted) (internal quotation marks omitted).
[74] There is a longer-term worry of bioaccumulation further up the marine food chain. *Id.* at 4 (citing Elizabeth Rosenthal, *Radiation, Once Free, Can Follow a Tricky Path*, N.Y. TIMES, Mar. 22, 2011, at A11, *available at* http://www.nytimes.com/2011/03/22/science/earth/22food.html). However, the U.S. Food and Drug Administration (the "FDA") implemented a multi-tiered import alert for fish from the area. BUCK & UPTON, *supra* note 70, at 5. A more immediate concern appears to be the accumulation of radioactive material in the nearby seafloor, possibly tainting bottom-feeding seafood for decades. Hiroko Tabuchi, *Fish off Japan's Coast Said to Contain Elevated Levels of Cesium*, N.Y. TIMES, Oct. 26, 2012, at A4, *available at* http://www.nytimes.com/2012/10/26/world/asia/fish-off-fukushima-japan-show-elevated-levels-of-

The third possible radiation vector studied was wind. While monitors did detect trace amounts of radiation in rainwater in early April 2011 in California, Idaho, and Minnesota, these amounts were too low to endanger the U.S.[75] The fourth and final possible vector for radiation pollution was the contaminated debris swept away from the site.[76] This too posed little danger of contamination.[77] However, other dangers pertain to the floating debris field. In fact, "a derelict 150-foot Japanese fishing vessel, spotted off the British Columbia coast in March 2012, was sunk by the U.S. Coast Guard as a hazard to navigation."[78] Thus, besides contaminated fish imported from the Western Pacific and stray debris in shipping lanes, the disaster had little in the way of direct effects on the U.S.

B. The Effect Of Fukushima On The Current Domestic Nuclear Community

While the events at Fukushima did not result in any direct danger to the U.S., the domestic nuclear community certainly responded to these events. The Institute of Nuclear Power Operations (INPO) compiled one of the most comprehensive studies of Fukushima and generated an addendum containing lessons that can be learned from the incident.[79] The nuclear industry formed INPO in the wake of TMI and the subsequent Kemeny Commission report.[80] As the industry's representative , INPO "promot[es] the highest levels of safety and reliability – to promote excellence – in the operation of commercial nuclear power plants."[81] In furtherance of this self-imposed mandate, INPO studied the events at Fukushima and came to several conclusions.

Among others, INPO identified two important positive lessons that the domestic

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cesium.html. However, the FDA is still actively screening fish imported from Japan in anticipation of such a danger. *Radiation Safety*, U.S. FOOD AND DRUG ADMIN. (June 6, 2012), http://www.fda.gov/NewsEvents/PublicHealthFocus/ucm247403.htm.

[75] BUCK & UPTON, *supra* note 70, at 2.

[76] *Id.* at 7.

[77] Ken Buesseler, *FAQ: Radiation from Fukushima*, WOODS HOLE OCEANOGRAPHIC INST. (Aug. 28, 2013), http://www.whoi.edu/page.do?pid=83397&tid=3622&cid=94989.

[78] *Id.* (citation omitted).

[79] *See* INPO, LESSONS LEARNED FROM THE NUCLEAR ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION (2012).

[80] *About Us*, INST. OF NUCLEAR POWER OPERATIONS, http://www.inpo.info/AboutUs.htm (last visited Oct. 12, 2015).

[81] *Id.*

nuclear industry should internalize from Fukushima. The first lesson was the value of the emergency response centers (ERCs) in place at Fukushima.[82] Emergency response centers are seismically-isolated facilities that allow some measure of control.[83] In addition to a limited amount of control over on-site systems, ERCs allow monitors to track the statuses of various systems, in order to inform emergency response actions.[84] The information deficit often inherent in a natural disaster limited the effectiveness of TEPCO's response actions. However, the monitoring information provided by the ERC's was instrumental in limiting the inadequacies of response methods. Another bright spot from the Fukushima disaster was the "innovative and resourceful actions" employees took in response to ever-changing disaster conditions.[85] This point is particularly noteworthy in constituting a significant example of universal progress in the training of nuclear plant operators, as both TMI and Chernobyl were primarily considered the result of human error.[86]

INPO also identified some "significant operational lessons" that the Fukushima disaster and TEPCO's emergency response can teach the domestic nuclear community.[87] INPO found that Fukushima served as a sharp reminder of the need for a redundant and multi-layered emergency response plan.[88] It is not unreasonable to dismiss this conclusion as merely a product of hindsight bias, especially given that this disaster was arguably unpredictable, but the magnitude of the potential harm from any nuclear accident militates in favor of emphasizing safety before cost.[89] While every plant must have design basis parameters rooted in certain specifications, INPO recognized that having a flexible and redundant response plan, particularly one that contemplates beyond

[82] INPO, *supra* note 79, at 4.
[83] *Id.* at 11.
[84] *Id.* at 12.
[85] *Id.* at 4.
[86] *See generally* HOLT ET AL., *supra* note 57, at 1.
[87] *See* INST. OF NUCLEAR POWER OPERATIONS, *supra* note 79, at 4–5.
[88] *Id.* at 4.
[89] *Id.* at 10; *see* Adam J. White, *Thinking About the "Practically Unthinkable": Energy Infrastructure and the Threat of Low-Probability, High-Impact Events*, 12 ENGAGE: J. FEDERALIST SOC'Y PRAC. 3 (2011).

design-basis events, is a necessity for a nuclear plant.[90] Despite their praise of the TEPCO employees' response, INPO also identified the need for better employee training.[91] Specifically, INPO suggested that the required training needs to simulate beyond design-basis events and decision-making that may endanger human life.[92] Finally, INPO recognized flaws inherent to TEPCO's culture, as there were practically no accessible avenues for challenging assumptions and decisions made by supervisors within the company.[93] Given INPO's report, it is now necessary to consider the effects these recommendations could have on the domestic nuclear community.

## C. Nuclear Energy's Role In America's Future

### 1. *Current Political Atmosphere*

The reception of INPO's report depends not only on the inherent value of the lessons described therein, but also on the current state of the domestic nuclear community. While the following discussion is by no means a comprehensive treatment of the state of this community, there are several important factors that affect how it will receive INPO's report. Indeed, the community's reaction to this report will be a telling study in the community's ability to respond to stakeholder input.

The first factor controlling recent nuclear developments is the Energy Policy Act of 2005 (EPAct).[94] This legislation codified another round of subsidies for the nuclear industry,[95] hoping to incentivize further nuclear development. Specifically, EPAct provides for loan guarantees for new nuclear facilities.[96] In the EPAct, a loan guarantee is a "binding agreement by [the Department of Treasury (the 'Treasury')]"[97] that the Treasury will pay "a part of the principal or interest on [many but not all types of] debt

[90] *See* INST. OF NUCLEAR POWER OPERATIONS, *supra* note 79, at 5, 28.
[91] *Id.* at 5.
[92] *Id.*
[93] *Id.* at 5, 33–36.
[94] Energy Policy Act of 2005, Pub. L. No. 109–58, 119 Stat. 594 (2005).
[95] 42 U.S.C. § 16512(c) (2006).
[96] EPAct, § 1702, 119 Stat. at 1118.
[97] 2 U.S.C. § 661a(4) (2006) (defining "loan guarantee commitment"); *see* 42 U.S.C. § 16511(4)(A), (B) (2006).

obligation[s] of a non-Federal borrower to a non-Federal lender."[98] Upon meeting certain conditions set out in 42 U.S.C. § 16512(b), the Treasury can provide "advanced nuclear energy facilities" with a guarantee of "an amount equal to [eighty] percent of the project cost of the facility that is the subject of the guarantee, as estimated at the time at which the guarantee is issued."[99] The incentives are aimed at overcoming the high cost of construction, which the industry views "as critical for proceeding with new nuclear power plants."[100] Put simply, "[t]o make new nuclear power economically viable in its private enterprise system of energy delivery, the current and presumed form for necessary subsidies is government financial guarantees for a high fraction of plant costs."[101] Thus, the EPAct's generous loan guarantees implicitly signal Congress's recognition of this need for subsidies to make nuclear power viable and their concurrent desire to promote new nuclear production.

Despite the domestic promotion of new nuclear construction in the face of mounting countervailing forces, it is informative to look outside the U.S. at the response of other similarly situated nations have responded to the same influences. As the nation most affected by the Fukushima disaster, the Japanese government's response was understandably extreme.[102] The Japanese Prime Minister Naoto Kan "ordered a complete review of the role of nuclear energy in Japan's future energy mix and announced a target for renewable electricity to reach [twenty percent] of total supply by 2030."[103] The implication of this twenty percent renewable goal being that nuclear would play a significantly reduced role in Japan's energy future.[104] Thus, Japan responded to the

[98] 2 U.S.C. § 661a(3) (2006).
[99] 42 U.S.C. §§ 16014(a)(1), 16512(c) (2006).
[100] Stone, *supra* note 6, at 89.
[101] *Id*. at 102.
[102] *See* James Prest, *Summary: Law and Policy to Advance Renewable Energy: A Comparative Colloquium*, 2 RENEWABLE ENERGY L. & POL'Y REV. 171, 171-73 (2011).
[103] *Id.* at 171 (citing *Pursuing a New Energy Policy*, THE JAPAN TIMES ONLINE [June 11, 2011], available at http://search.japantimes.co.jp/cgi-bin/ed20110611a1.html.
[104] At least in the short term, nuclear energy has ceased to play any role in Japanese electricity generation. *See Japan's Fuel Imports Contribute to Record Trade Deficit*, UNITED PRESS INT'L (Jan. 27, 2014), http://www.upi.com/Business_News/Energy-Resources/2014/01/27/Japans-fuel-imports-contribute-to-record-trade-deficit/UPI-49811390851293/. Furthermore, Japan has followed through on its plans to develop renewable energy sources. *See* David J. Unger, *Clean Energy Investment Down, but Not Out*, THE

disaster by fundamentally changing the place of nuclear energy within their electricity production portfolio.

One could view this extreme response as a political overreaction to appease a deeply wounded nation. However, Germany's reaction to the incident was equally as strong. In 2010, nuclear energy provided over twenty-five percent of Germany's electricity.[105] While it provided almost a quarter of Germany's electricity, Germany's nuclear industry was a source of debate pre-Fukushima.[106] Despite the varied public opinions, nuclear power had the support of Chancellor Angela Merkel, who went so far as to reverse "the *Atomausstieg* [nuclear power exit] of autumn 2010."[107] In response to Fukushima, the German Cabinet passed a 2022 phase-out program for all German nuclear reactors (subject to Parliamentary approval), which then received the support of Chancellor Merkel.[108] In addition, Germany immediately shut down around forty percent of its nuclear generating capacity in the wake of Fukushima.[109] These international examples do not have any direct bearing on the American nuclear community, but it is necessary to note the dark clouds hanging over the nuclear energy industry in nations similar to the U.S. This international disfavor may serve to further reinforce the domestic stakeholders that urge for further regulation of the nuclear industry.

### *2. Low-Risk/High-Cost Events*

An important question posed by the disaster at Fukushima is how low-risk/high-cost events will be viewed by the domestic nuclear community. INPO's Report explicitly recognized that "low-probability, high-consequence threats need additional attention" in

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CHRISTIAN SCI. MONITOR (Jan. 15, 2014), http://www.csmonitor.com/Environment/Energy-Voices/2014/0115/Clean-energy-investment-down-but-not-out ("Japan bucked the trend, with investment soaring 55 percent to $35.4 billion as the country leveraged small-scale solar to replace the nuclear power it took offline").

[105] *Nuclear Power in Germany*, WORLD NUCLEAR ASSOCIATION, http://www.world-nuclear.org/info/inf43.html (last visited Oct. 12, 2015).

[106] Prest, *supra* note 102, at 171.

[107] *Id.* (citation omitted).

[108] *Id.*

[109] *The German Switch from Nuclear to Renewables – Myths and Facts*, RENEWABLES INTERNATIONAL: THE MAGAZINE (Sept. 3, 2012), http://www.renewablesinternational.net/the-german-switch-from-nuclear-to-renewables-myths-and-facts/150/537/33308/.

the nuclear community's risk assessment methodologies.[110] This recognition is all the more important given Congress's codified intent to promote new nuclear development. As that sentiment does not appear to be declining, the domestic nuclear community must account for these events in its regulation of new and existing nuclear reactors.

Also contributing to this risk management calculus are several other important factors. The first factor that supports more comprehensive regulation of nuclear reactor sites is the lack of offsite storage options for nuclear waste. Such regulation is vital to future nuclear development. The only real offsite option explored by the community in recent years, Nevada's Yucca Mountain, appears to be too controversial. Despite beginning proceedings to consider the Yucca Mountain site as a nuclear waste depository, the Department of Energy withdrew its application from the NRC and "[t]he licensing proceeding has been formally suspended."[111] This suspension resulted from intense opposition by many parties, including Harry Reid, Democratic Senator from Nevada and majority leader of the Senate. Not so delicately, a spokesperson for Senator Reid said that, "[a]s long as Senator Reid is majority leader, there will not be a Yucca Mountain. . . . Yucca Mountain will be dead."[112] This forces nuclear operators to store their waste on-site. When natural disasters strike nuclear reactors, they also affect these storage facilities. Barring any new off-site storage facilities, the amount of waste stored on-site at every nuclear plant will only continue to increase over time. This waste problem inherently increases the risk of contamination and raises the cost any natural disaster causes to a given nuclear plant.

Another factor motivating better planning for low-risk/high-cost events is the effect of climate change on sea level rise and storm surge levels.[113] Many nuclear reactors

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[110] INST. OF NUCLEAR POWER OPERATIONS, *supra* note 79, at 12.

[111] Tyson Smith & Tison Campbell, *The Outlook for Nuclear Power Across the United States and Globally*, AMER. BAR ASS'N TRENDS, Mar./Apr. 2012, at 11.

[112] Eliot Marshall, *Reid Victory Likely to Keep Yucca Mountain Sealed*, SCIENCE INSIDER (Nov. 3, 2010), http://news.sciencemag.org/scienceinsider/2010/11/reid-victory-likely-to-keep-yucca.html (quoting a spokesperson for Senator Reid).

[113] While no one storm can be attributed to climate change, climate change will increase the magnitude and effects of future storms, specifically regarding high coastal water events. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE

are in close proximity to either the coast or a major river.[114] Using a conservative projection, the International Atomic Energy Agency (IAEA) advised that nuclear operators should consider a rise in mean sea level of thirty-five to eighty-five centimeters, an increase in both air and water temperatures, and a resulting increase in storm surge levels.[115] As the projections regarding the severity of climate change have only grown increasingly dire since the IAEA's report,[116] the threats posed by a rising sea and more extreme storm surges are greater now than they were in 2003 when the study's data were collected. Although not directly applicable to the situation at Fukushima, given the proximity of many nuclear plants to flood-prone areas, it is clear that the domestic nuclear community must begin to better plan for extreme weather events.

## IV. CONCLUSION

Despite some of the problems inherent in planning for low-risk/high-cost events,[117] the ever-growing magnitude of the cost associated with a disaster at a nuclear plant necessitates changes in the way the domestic nuclear community plans for low-risk/high-cost events. There are three identifiable factors that will influence the domestic nuclear community for the foreseeable future. First, the nuclear energy community experienced a steady growth in public input and there are no signs that such input will

CHANGE ADAPTATION (2012), http://www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf. This increase may make the design basis of some nuclear plants inadequate. FUEL FIX, *Nuclear-power Industry Survives Sandy's Readiness Test*, (Oct. 31, 2012), http://fuelfix.com/blog/2012/10/31/nuclear-power-industry-survives-sandy's-readiness-test/. Indeed, this danger is not limited to storm events, as increasing water resource temperatures can make water too warm to function as a coolant for a nuclear plant. Jan Ellen Spiegel, *Climate Change Puts Nuclear Plants at Risk of Shutdown*, (Sept. 25, 2012), http://www.eenews.net/climatewire/rss/2012/09/25/9. Regardless of the particular danger, the continued viability and safety of domestic nuclear reactors' aging infrastructure in light of climate change is uncertain. *Nuclear-power Industry Survives Sandy's Readiness Test*, *supra note 113*.

[114] Sean Pool et al., *Climate Change Could Create New Risk to U.S. Reactor Safety*, SCIENCE PROGRESS (Mar. 31, 2011), http://scienceprogress.org/2011/03/climate-change-could-create-new-risks-to-u-s-nuclear-reactor-safety/.

[115] INT'L ATOMIC ENERGY AGENCY, IAEA SAFETY STANDARDS SERIES: FLOOD HAZARD FOR NUCLEAR POWER PLANTS ON COASTAL AND RIVER SITES 72-73 (2003), http://www-pub.iaea.org/MTCD/publications/PDF/Pub1170_web.pdf.

[116] *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

[117] White, *supra* note 89, at 8.

stop.[118] Second, as demonstrated above, the magnitude of harm and likelihood of such harm occurring will continue to increase. Third, the federal government put in place a framework for the expansion of the nuclear industry that will continue to incentivize new construction. These three factors often conflict in the effect they have, and will continue to have, on the nuclear community.

Rather than ignoring this friction, the domestic nuclear community must embrace the information that outside groups can provide in planning for future low-risk/high-cost events. As noted above, low-risk/high-cost events are difficult to plan for, partially because the attendant risks and effects are difficult to quantify. The increased number of qualified and active nuclear stakeholders can cooperatively work towards quantifying these risks. Undoubtedly, this new nuclear community will not be as swift, efficient, and single-minded as the AEC/JCAE of old was. However, the community will not shrink in the foreseeable future, making the prudent path the one that utilizes the resources of this expanded community to further the goals of all stakeholders. Rather than resisting this growing community, the friction generated by the often-contrasting interests of various nuclear stakeholders should drive more fully informed decisions by government and private stakeholders, and improve the safety and reliability of nuclear energy in the years to come.[119]

[118] The NRC continues to work with a number of stakeholders in their response. UNITED STATES NUCLEAR ENERGY COMM'N, *Implementing Lessons Learned from Fukushima: Public Meetings/Presentations*, http://www.nrc.gov/reactors/operating/ops-experience/japan/japan-meeting-briefing.html (Aug. 12, 2013).
[119] For a discussion of how best to include non-state actor input in a regulatory framework, see generally Hari M. Osofsky, *Multidimensional Governance and the BP Deepwater Horizon Oil Spill*, 63 FLA. L. REV. 1077 (2011).