Oil and Gas, Natural Resources, and Energy Journal

Volume 7 | Number 1

August 2021

Are You In or Are You Out? An International Comparison of Nuclear Integration or Discontinuation

Tyler Self

ONE J

Oil and Gas, Natural Resources, and Energy Journal

VOLUME 7 NUMBER 1

ARE YOU IN OR ARE YOU OUT? AN INTERNATIONAL COMPARISON OF NUCLEAR INTEGRATION OR DISCONTINUATION

TYLER SELF*

Table of Contents

* University of Oklahoma College of Law J.D. Candidate 2022. Thank you to Professor Carolina Arlota, University of Oklahoma College of Law, for the extensive research assistance and editing provided. Additionally, many thanks to my friends and family who supported me through my first major publication process.

I. Introduction

"Nuclear power is a hell of a way to boil water:"[1] words of famed theoretical physicist, Albert Einstein, on the star of the Nuclear Age. While this is an over-simplification of the complex processes of nuclear energy, it does help showcase another simple but true statement. The answer to combatting climate change is simple: Nuclear Power. Whether the future is entirely renewable-based or a combination of renewables and nuclear remains to be seen. But now, nuclear power is the best available option to create clean, reliable, and efficient energy throughout the world without the horrific side-effects of fossil-fuel led programs. Our daily lives are intertwined with the fossil-fuel industry in more than just an energy capacity, but the effects of fossil fuels on the Earth and its people are indisputable.

The purpose of this article is to evaluate twelve countries' future plans and views on nuclear power. The list is divided between six countries which plan to maintain/increase their use of nuclear power and six countries which plan to decrease/eliminate their use of nuclear power. The connecting thread throughout is the effects the world's most infamous nuclear accidents had on these countries' policies and popular support levels.

Section II of this article discusses the background of nuclear power and some of the implications of becoming a nuclear state. Section III discusses the three major nuclear accidents and the consequences that followed. Section IV begins the cataloging of countries and defines the comparisons. Section V focuses on countries choosing to opt-in, and Section VI focuses on countries choosing to opt-out. Section VII discusses the implications of these countries choosing either of these options. Finally, Section VIII is a conclusionary section to finalize any details.

1. Helen Caldicott, *After Fukushima: Enough is Enough*, N.Y. TIMES (Dec. 2, 2011), https://www.nytimes.com/2011/12/02/opinion/magazine-global-agenda-enough-is-enough.html.

II. Background

"Now I am become Death, the destroyer of worlds."[2] These famous words by Robert Oppenheimer heralded not only the dawn of the nuclear age but also the origins of nuclear power. The intertwining of nuclear weapons and civil nuclear power is an important connection to note, with the latter evolving out of the research of atomic weapons. Around the time of World War II, most nuclear power research was for the military or government-funded programs. This changed with President Eisenhower signing the Atomic Energy Act of 1954 which helped to declassify U.S. reactor information and incentivize privatized research.[3] While this is just one example of the countless similar programs launched around the world it was the dawn of the American Atomic Age.

The Atomic Age saw many advances in nuclear power, but came with important, yet painful, lessons. We stand at a cross-roads of our world's climate future and nuclear energy provides a chance to solve many of these problems, but not without risks. Despite its connection to world ending weapons, the positives that nuclear power has provided and will continue to provide are enormous. The development of improved reactors, updated safety processes, and regulatory agencies was a collaborative international effort that has had relatively smooth sailing. Currently, many international organizations provide oversight and support for both established and fledgling programs.

These International nuclear agreements and treaties include provisions regarding immediate accident notification, research exchanges, clean-up commitments, ensuring safe and closed fuel cycles, and non-proliferation among non-member states. Some of the most important treaties include the International Atomic Energy Agency ("IAEA") Convention on Early Notification of a Nuclear Accident treaty and the IAEA Convention on Nuclear Safety. These two establish many of the mandatory protocols for countries wishing to remain party to other discussions on nuclear power.

The 1986 IAEA Convention on Early Notification of a Nuclear Accident was created in response to the accident at Chernobyl that occurred not five

2. Jessica Sleight, *Scientists and the Bomb: 'The Destroyer of Worlds'*, GLOBAL ZERO (Jul. 25, 2019), https://www.globalzero.org/updates/scientists-and-the-bomb-the-destroyer-of-worlds/.

3. 42 U.S.C. §§ 2011, et seq. (2021).

months prior.[4] It requires ratifying states to establish rapid response protocols for any nuclear accident occurring within its borders—specifically those that could potentially affect neighboring states or the globe.[5] States are required to give notice to the IAEA and neighboring states regarding the time, location, reason, and the assumed release amount of radioactive particles.[6] These obligations are built out of the *Trail Smelter* theory, which established the requirements of states regarding pollution and environmental harms crossing international borders.[7] Currently, Japan and France are the only non-ratifying countries within this article with each merely accepting and approving the proposal without formal ratification.[8]

The 1994 IAEA Convention on Nuclear Safety establishes the international standards ratifying states needed to implement in civilian facilities.[9] This includes substantial reviews of all operating reactors, safety protocols, risk assessments, and other various checkups on their entire nuclear fleet.[10] The establishment of international standards was difficult as countries were at various levels of development and some operating with imperfect reactor technology. The treaty also establishes a comprehensive year-end review by the IAEA on member countries and the subsequent goals of the organization.[11] Of the compared states within this article, all are ratified members except Russia, Japan, and France, which have accepted without ratification.[12] Member states are also usually members of clean-up commitment treaties promising the state's ability and willingness to provide needed assistance in cases of catastrophic accidents in other member countries.

---

4. *Convention on Early Notification of a Nuclear Accident (ENC)*, NEA, https://www.oecd-nea.org/jcms/pl_29135/convention-on-early-notification-of-a-nuclear-accident-early-notification-convention (last visited Jan. 31, 2021).

5. *Convention on Early Notification of a Nuclear Accident*, IAEA (Nov. 18, 1986), https://www.iaea.org/sites/default/files/infcirc335.pdf.

6. *Id.*

7. *Trail Smelter Case (United States, Canada)*, United Nations (2006), https://legal.un.org/riaa/cases/vol_III/1905-1982.pdf.

8. *Convention on Early Notification of a Nuclear Accident*, IAEA (Sep. 09, 1986), https://treaties.un.org/Pages/showDetails.aspx?objid=08000002800cf3c9

9. *Convention on Nuclear Safety*, NTI (Aug. 31, 2020), https://www.nti.org/learn/treaties-and-regimes/convention-nuclear-safety/.

10. *Id.*

11. *Id.*

12. *Convention on Nuclear Safety*, IAEA (Sep. 9, 1994), https://treaties.un.org/Pages/showDetails.aspx?objid=08000002800a52b4.

III. Catastrophic Accidents

"As long as nuclear engineering can strive for new innovations and learn from its history of accidents and mistakes, the benefits that nuclear power can yield for our economy, society, and yes, environment, will come."[13] The accidents that occurred at Three Mile Island, Chernobyl, and Fukushima Daiichi (The "Big 3") are the most widely known nuclear accidents in the world. These events had profound environmental impacts and, in the case of Chernobyl, were even felt in neighboring countries. Additionally, each has shaped nuclear regulation and public opinion within their own countries and globally.[14]

In any case involving a nuclear accident the IAEA uses the International Nuclear and Radiological Event Scale ("INES") to compare the accidents to others. It is a logarithmic scale in which each level reflects a ten-fold increase in severity.[15] The INES scale focuses primarily on the environmental and human impact, the impact on radiological barrier and control, and defense-in-depth of the reactor.[16] Other factors serve as secondary indicators to either increase or decrease the final rating. For reference: the Chernobyl accident was a 7; the Fukushima Daiichi accident was a 7; and the Three Mile Island accident was a 5.[17] On the INES scale, any event that receives a 4 or higher is classified as an "Accident" while anything that receives a 3 or lower is an "Incident."[18] While there are valid criticisms against the scale's application and design, such as inconsistent ratings and bad comparative ability, it is still a useful tool when comparing nuclear accidents and incidents around the globe.[19]

---

13. James Mahaffey, *Atomic Accidents: A History of Nuclear Meltdowns and Disasters: From the Ozark Mountains to Fukushima* 112, (Pegasus Books, February 4, 2014).

14. The discussion of these accidents is extremely simplified and condensed due to spatial constraints. This does not downplay the extreme impact these accidents had. Along with the complexity of nuclear engineering being difficult to explain in a condensed format.

15. *International Nuclear and Radiological Event Scale (INES)*, IEAE, https://www.iaea.org/resources/databases/international-nuclear-and-radiological-event-scale (last visited Nov. 11, 2020).

16. *Id.*

17. *Types of Nuclear Accidents: INES Scale*, NUCLEAR ENERGY, https://nuclear-energy.net/nuclear-accidents/ines-scale.html (last visited Nov. 15, 2020).

18. *Id.*

19. Spencer Wheatley, Benjamin Sovacool, and Didier Sornette, *Of Disasters and Dragon Kings: A Statistical Analysis of Nuclear Power Incidents and Accidents*, CORNELL PHYSICS (Apr. 7, 2015), https://arxiv.org/abs/1504.02380.

A. Three Mile Island 1979

"It was an accident destined to threaten not only the lives of thousands, born and unborn, but also the future of nuclear power itself."[20] The Three Mile Island ("TMI") accident was the most serious accident in American nuclear power plant history, and its short and long term effects are still felt by the nation.[21] While the actual environmental and public health impacts were non-existent compared to Fukushima Daiichi and Chernobyl it still acted as the major driving force in the derailing of nuclear energy in America's civilian sector.[22]

The TMI accident began around 4 A.M. on March 28, 1979, within the plant's Nuclear Generating Station TMI-2 Reactor.[23] A mechanical or electrical failure prevented the main water pumps from being able to send water into the steam generators, which blocked the dissipation of heat from the reactor core.[24] A lack of heat dissipation caused the core's temperature to rise rapidly, initiating a reactor shutdown within one second of overheating.[25]

A relief valve was opened to stop internal pressure from continuing to rise.[26] Unfortunately, as the plant's system incorrectly indicated the valve had closed, it remained open.[27] This caused a coolant leak, which in time caused the heat dissipation system to fail.[28] Following the leak and coolant failure, a portion of the water became irradiated and vaporized which then escaped into the outside atmosphere.[29] The amount of radiation released from this gas was shown to be insignificant in terms of public health,

---

20. B. Drummond Ayres Jr., *Three Mile Island: Notes from a Nightmare*, N.Y. TIMES (Apr. 16, 1979), https://www.nytimes.com/1979/04/16/archives/three-mile-island-notes-from-a-nightmare-three-mile-island-a.html

21. *Backgrounder on the Three Mile Island Accident*, NRC (Jun. 21, 2018), https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.

22. David Dalton, *Three Mile Island Led to 'Sweeping and Permanent' Changes*, NUCNET (Mar. 23, 2009), https://www.nucnet.org/news/three-mile-island-led-to-sweeping-and-permanent-changes.

23. *Three Mile Accident*, World Nuclear Accident (March 2020), https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/three-mile-island-accident.aspx.

24. *Id.*

25. *Id.*

26. *Id.*

27. *Id.*

28. *Id.*

29. *Backgrounder on the Three Mile Island Accident*, NRC (Jun. 21, 2018), https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.

though it still shattered public belief in the safety of the situation.[30] Currently there have been no linkages to any environmental harms or adverse health effects caused by the TMI accident.[31]

Following the vapor release, a bubble of Hydrogen gas began forming in the reactor causing the monitoring team to fear a massive explosion.[32] This potential explosion caused a continuing rise in public fear in the surrounding area.[33] It took the monitoring team over a month to place the reactor into a workable state, only achieving "cool shutdown" in late April.[34] During this period massive miscommunications by various agencies and state officials exacerbated fear in a controlled situation.

In a storm of perfect coincidence, twelve days before the TMI accident the film *The China Syndrome* premiered.[35] The premise of the film is about a fictional nuclear reactor that experiences a meltdown extremely similar to that of the TMI reactor.[36] In an amazing coincidence, Jane Fonda's character even says the explosion could render a state the size of Pennsylvania, the location of the TMI accident, uninhabitable.[37] This film's release primed the public to overreact severely to the situation. The film, combined with conflicting messages by regulatory agencies, created an increased level of public fear and outcry. The NRC later confirmed the reactor was not at risk of a "China Syndrome" style meltdown. Much of the reaction to the accident was confined to the United States, with a harsh decline in belief of nuclear safety and viability along with sweeping legislative changes.

---

30. *Id.*

31. *Lessons from the 1979 Accident at Three Mile Island*, NEI (Oct. 2019), https://www.nei.org/resources/fact-sheets/lessons-from-1979-accident-at-three-mile-island.

32. *Three Mile Accident*, World Nuclear Accident (March 2020), https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/three-mile-island-accident.aspx.

33. *Id.*

34. *Id.*

35. David Burnham, *Nuclear Experts Debate 'The China Syndrome'*, N.Y. TIMES, (Mar. 18, 1979), https://www.nytimes.com/1979/03/18/archives/nuclear-experts-debate-the-china-syndrome-but-does-it-satisfy-the.html.

36. *Id.*

37. Ron Southwick, *Three Mile Island accident was eerily foreshadowed by a Hollywood blockbuster days before*, PennLive (Mar. 17, 2019), https://www.pennlive.com/news/2019/03/the-three-mile-island-accident-followed-a-hollywood-blockbuster.html.

B. Chernobyl 1986

The Chernobyl nuclear accident is the most well-known nuclear event, barring the use of atomic weapons in World War Two. The accident has spawned countless books, documentaries, and pop culture references for decades. Following the Chernobyl accident, the nations of the world experienced a dramatic shift in their views and future intentions regarding nuclear energy. It is arguably the most important event in the history of civil nuclear power. While the Chernobyl accident is technically a 7 on the INES scale, it is such an anomalous figure it shatters the scale if included.[38] It is the only accident in which direct radiation-related fatalities occurred.[39]

It is estimated that 400 times more radioactive material was released from the Chernobyl accident than the combined bombings of Hiroshima and Nagasaki.[40] The impact of the accident cannot be understated in any manner. However, the precursors to the accident stem from a unique reactor only in the Eastern Bloc and a complete lack of safety culture surrounding nuclear reactors.[41] While this does not excuse the complete failure, it does make it less applicable to the nuclear industry of outside countries. But this distinction did nothing to help contain or temper the international reaction: the effects of Chernobyl on public opinion and legislative efforts are still occurring today.

The Chernobyl Accident began on April 25, 1986, with a planned system shutdown to test a new voltage regulator design to implement within the reactors.[42] As the shutdown process occurred, a voltage increase (ironically enough) caused a temperature increase of the system.[43] With an increase in temperature came an increase in internal pressure via steam build up.[44] Eventually, the continued rising internal pressure caused the containment system to fail, triggering a massive explosion that killed two and wounded

38. Don Higson, *Don't Compare Fukushima to Chernobyl*, (Mar. 14, 2012), https://www.newscientist.com/article/mg21328566-500-dont-compare-fukushima-to-chernobyl.

39. *Chernobyl Accident and Its Consequences*, NEI (May 2019), https://www.nei.org/resources/fact-sheets/chernobyl-accident-and-its-consequences.

40. *Backgrounder on Chernobyl Nuclear Power Plant Accident*, USNRC, (Aug. 2018), https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/chernobyl-bg.html.

41. *Chernobyl Accident 1986*, WORLD NUCLEAR ASS'N (Apr. 2020), https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx.

42. *Id.*

43. *Id.*

44. *Id.*

more.[45] This explosion released over 1,200 tons of high temperature graphite, causing massive fires within the reactor and surrounding building.[46] This explosion spewed a massive quantity of radioactive material over Europe in the following weeks.[47]

The immediate impact was devastating, and the long-standing effects are still occurring. Almost immediately, over 350,000 residents were evacuated and will likely never return to their homes, nor will anyone for over 20,000 years.[48] There were twenty-eight eventual deaths via acute radiation syndrome of workers with no radiation deaths occurring with outside residents.[49] These impacts do not include the environmental effects the meltdown had on the surrounding ecology and neighboring states.

The impact of Chernobyl on public opinion regarding nuclear power was quick and harsh. Concurrently, developed programs around the globe acted in lockstep to stop and review their own nuclear programs with many responding with full shutdowns. Additionally, The Chernobyl accident was an incriminating exposure of the U.S.S.R.'s lack of control and management of its Bloc Countries. Mikhail Gorbachev even said the Chernobyl accident was a more important factor in the dissolution of the Soviet Union than his failed economic reform policies.[50]

C. Fukushima 2011

"Fukushima Daiichi began with a double whammy: the 8.9-magnitude earthquake off the coast of Japan that apparently knocked out its main source of electrical power and the resulting tsunami that put the facility's backup power supply out of commission."[51] This combination would destroy almost any reactor around the world. The combined effects of the sources losing their main functions and cooling abilities coupled with the

45. *Id.*

46. *Id.*

47. *Id.*

48. Yoana Cholteeva, *Making Chernobyl safe: A timeline*, POWER TECHNOLOGY (Jun. 30, 2020), https://www.power-technology.com/features/making-chernobyl-safe-a-timeline/.

49. *Chernobyl Accident 1986*, WORLD NUCLEAR ASS'N (Apr. 2020), https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx (There were around 7000 cases of thyroid cancer with 15 deaths).

50. Mikhail Gorbachev, *Chernobyl 25 years later: Many lessons learned*, BULLETIN OF THE ATOMIC SCIENTISTS (Aug. 2011) https://www.tandfonline.com/doi/abs/10.1177/0096340211399746?journalCode=rbul20.

51. Howard Chua-Eoan, *How to Stop a Nuclear Meltdown*, TIME (Mar. 12, 2011), http://www.time.com/time/world/article/0,8599,2058615,00.html.

loss of two layers of emergency power led to a "station blackout."[52] The statistical probability of this scenario was so low that many found it unlikely to ever occur.[53]

The events preceding the Fukushima Daiichi Accident ("Fukushima") began on March 11, 2011.[54] At 2:46 P.M., the "Great East Japan Earthquake" (8.9 magnitude) occurred 150 miles off the coast of Japan's Honshu Island (the main island of Japan).[55] After the initial earthquake, the Fukushima Reactors shut down with accordance to their seismic activity detection protocol.[56] At this time no major damage had occurred to the reactors, but external power had been disabled and emergency diesel generators kicked in to continue cooling operations.[57]

According to Tokyo Electric Power Company ("TEPCO"), the company operating the Fukushima Daiichi reactors, only Units 1–3 of 6 reactors were in operation during the earthquake.[58] Therefore, in theory, the problem could have been contained after reestablishing external power and restarting the normal functions. Unfortunately, at 3:42 P.M. and 3:50 P.M., two colossal tsunami waves hit and flooded the reactor plant, destroying the diesel back-up generators.[59] Additionally, the flooding destroyed the electrical switch gear of the reactors and made accessing the systems extremely difficult.[60]

With reactors 1–3 not having access to their residual heat removal systems or water pumps reactor meltdowns began to occur.[61] Within the reactors major fuel melting occurred due to overheating though it initially

---

52. *Id.*

53. *Id.*

54. *Fukushima Daiichi Accident*, WORLD NUCLEAR ASS'N (May 2020), https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident.aspx.

55. *Id.*

56. *Id.*

57. *Id.*

58. *Plant Status of Fukushima Daiichi Nuclear Power Station (as of 0AM March 12th),* TEPCO Press Release (Mar. 12, 2011), https://www.tepco.co.jp/en/press/corp-com/release/11031203-e.html.

59. *Fukushima Daiichi Accident*, WORLD NUCLEAR ASS'N (May 2020), https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident.aspx.

60. *Japanese Earthquake Update (19 March 2011, 4:30 UTC)*, IAEA, https://web.archive.org/web/20110607091828/http:/www.iaea.org/press/?p=1463.

61. *Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station* 14–32*,* NRC, (Nov. 2011), https://www.nrc.gov/docs/ML1134/ML11347A454.pdf.

remained within the closed system.[62] An explosion occurred within Unit 4 which was in the process of refueling.[63] This caused some damage to Unit 3 and released material into the air.[64] A lasting issue is the pooling of irradiated water in nearby ground and the prevention of its spread into the environment.[65]

After the final investigation, the Fukushima accident ranked as a 7 out of 7 on the INES scale.[66] An interesting note is that the amount of radioactive materials discharged was only ten percent of the amount discharged in Chernobyl, another 7 on the INES scale.[67] The international reaction was similar to that of the world post-Chernobyl: Germany, Italy, and France committed to or doubled-down on the hardline phasing-out of nuclear power, while other nations used the lessons learned to improve safety standards and increase nuclear fleet capabilities.

IV. Comparison Catalog

The following two sections will compare countries' responses to the various reactor meltdowns discussed above. They examine integration of nuclear power into electrical grids and current plans to either increase or decrease nuclear reliance. Additionally, these sections examine public approval of nuclear power and the respective government's future plans.

This article focuses heavily on the Northern Hemisphere and includes no mention of Central/South American, African, Oceanian, and smaller South East Asian nations. Many of the excluded countries do not have nuclear reactors, but only plans for construction or a mere handful of reactors in operation. An interesting future topic would be the development of nuclear regulation and international policy in these countries, especially Northern Africa.

V. Opt-In Countries

This section focuses on countries that have chosen to "opt-in" to increasing or maintaining their reliance on nuclear power, whether through

62. *Id.*
63. *Id.*
64. *Id.*
65. *Id.*
66. *INES Rating on the Events in the Fukushima Daiichi Nuclear Power Station*, (Apr. 12, 2011), https://web.archive.org/web/20110501090736/http:/www.nisa.meti.go.jp/english/files/en20110412-4.pdf.
67. *Id.*

building new reactors, upgrading previously built ones, or purchasing excess power from neighboring countries.

A. United States

The United States is at a cross-road with its nuclear future with the people and government yearning for an increase in nuclear power, but all current plans seem dead in the water. The United States is the world's largest producer of nuclear power, having over thirty percent of the worldwide share of production.[68] Nuclear power produces around twenty percent of the nation's electricity, and over fifty-five percent of its carbon-free electricity.[69] These large production levels are accomplished through the operation of ninety-five commercial reactors throughout the United States, with the majority located East of the Mississippi River.[70]

As discussed above, the Three Mile Island accident caused a freeze on most American plans for nuclear power expansion, with more following the accident at Chernobyl. The effects of Chernobyl were severe, but somewhat mitigated by the carry-over resentment of the U.S.S.R. in the Cold War. Regardless, the increase of nuclear power output continued to rise overtime as reactors were updated and improved.[71] After each of these accidents, the civil energy sector conducted major internal reviews, resulting in U.S. standards subsequently surpassing most international standards.[72] However, the United States continued to halt reactor construction throughout the 2000s, despite the attempted nuclear renaissance.

The 'nuclear renaissance' was an attempted revival beginning with George Bush's Energy Policy of 2005—running in conjecture with his Nuclear Power 2010 program—which subsidized the nuclear sector as a response to fluctuating fossil-fuel prices around the globe.[73] After

68. *US Nuclear Power Policy*, WORLD NUCLEAR ASS'N (Oct. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx.

69. *Id.*

70. *Id.*, see also *Electricity in the United States*, ENERGY INFORMATION ADMIN. (Mar. 20, 2020), https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php.

71. *Annual Energy Review*, EIA (Sep. 27, 2012), https://www.eia.gov/totalenergy/data/annual/showtext.php?t=ptb0802a.

72. *Backgrounder on Chernobyl Nuclear Power Plant Accident*, US NRC (Aug. 2018), https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/chernobyl-bg.html.

73. John Quiggin, *Reviving nuclear power debates is a distraction. We need to use less energy*, THE GUARDIAN (Nov. 7, 2013), https://www.theguardian.com/commentisfree/2013/nov/08/reviving-nuclear-power-debates-is-a-distraction-we-need-to-use-less-energy; *see also US Nuclear Power Policy*, WORLD NUCLEAR ASS'N (Oct. 2020), https://www.

companies finished bidding, there were plans for thirty-one new nuclear reactors.[74] The current tally boasts two under construction, one commissioned, and two begun and subsequently cancelled.[75] These disruptions marked the death knell of Westinghouse, the last United States based new nuclear company, as the company accrued nine billion in debt from these failed projects, which forced a Chapter 11 bankruptcy.[76] The programs ran smoothly until the accident at Fukushima Daiichi chilled the U.S. government's views on the role of nuclear power going forward.

The effects were similar among industry experts with the safety of operating reactors the top priority, not new construction.[77] These companies conducted extensive reviews of all operating reactors scrutinizing the entire process from top to bottom. Major concerns were raised involving the location of boiling water reactors (the same style as those at Fukushima Daiichi) that were located near coastlines and/or areas of seismic activity.[78] These concerns carried over to the population itself.

The anti-nuclear movement has always been strong amongst the American populace with each of the Big 3 bolstering the groups supporters to strive for further restriction and removal of nuclear power. The movement stems from the long-running anti-nuclear weapons stance a portion of the country holds.[79] The prolific nature of the anti-nuclear movement in the US spawned dozens of groups, countless protests, and

---

world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx.

74. Brad Plumer, *U.S. Nuclear Comeback Stalls as Two Reactors Are Abandoned*, N.Y. TIMES (Jul. 31, 2017), https://www.nytimes.com/2017/07/31/climate/nuclear-power-project-canceled-in-south-carolina.html.

75. *Id.*

76. Taro Fuse, *Toshiba decides on Westinghouse bankruptcy, sees $9 billion in charges: sources*, REUTERS (Mar. 23, 2017), https://www.reuters.com/article/us-toshiba-accounting-idUSKBN16V04G.

77. Eric Wesoff, *Black & Veatch's 2011 Electric Utility Survey*, GTM (Jun. 16, 2011), https://www.greentechmedia.com/articles/read/black-veatchs-2011-electric-utility-survey-results.

78. Hannah Northey, *Japanese Nuclear Reactors, U.S. Safety to take Center Stage on Capitol Hill this week*, N.Y. TIMES (Mar. 28, 2011), https://archive.nytimes.com/www.nytimes.com/gwire/2011/03/28/28greenwire-japanese-nuclear-reactors-us-safety-to-take-ce-30444.html. *See also*, Michael Lemonick, *What the east coast earthquake for US Nuclear plants*, THE GUARDIAN (Aug. 24, 2011), https://www.theguardian.com/environment/2011/aug/24/east-coast-earthquake-nuclear-plants.

79. Elaine Woo, *Dagmar Wilson dies at 94; organizer of women's disarmament protestors*, L.A. TIMES (Jan. 30, 2011), https://www.latimes.com/local/obituaries/la-me-dagmar-wilson-20110130-story.html.

effective lobbying efforts that would require a novel-length cataloging account.

The public opinion on nuclear power has fluctuated in both directions throughout the history of the nuclear era, bottoming out after the Big 3. Despite this, post-2000s America has seen a strong support for not only the maintenance, but an increase in nuclear power as a whole. Prior to 2010, two-thirds of those polled supported nuclear power, with over half polling "strong" support.[80] The dip in support post-2011 was minimal at most and rebounded rather quickly, with over eighty percent considering the lessons learned and finding nuclear power plants safe.[81] These early 2000s numbers have continued into the 2020s with the support numbers remaining relatively unchanged.[82] The most showing support group is those who are "neighbors" of nuclear plants with ninety percent of those polled having a favorable view of their local plant.[83] The issue of this discontent between policy decisions and public support is an interesting angle to focus on as the new Biden administration implements its energy goals.

The United States is currently in nuclear power limbo with Biden committed to improving the sector while combatting the rising construction and maintenance costs. The Biden administration has plans of implementing "critical clean energy technologies," which includes nuclear power.[84] Both the Department of Energy and the Biden administration understand nuclear power is the key to curbing carbon emissions, especially as the United States rejoins the Paris Climate Accords.[85] The U.S. faces a difficult decision in the coming years regarding nuclear power, especially as the cost of fossil-fuels continues to drop sharply alongside increased effectiveness of shale gas and oil extraction. Additionally, the price of renewables continues to drop as the technology becomes more readily

80. *US Nuclear Power Policy*, WORLD NUCLEAR ASS'N (Oct. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx.

81. *Id.*

82. *Id.*

83. *Id.*

84. Caroline Delbert, *Nuclear Backers already like Joe Biden*, POPULAR MECHANICS (Feb. 1, 2021), https://www.popularmechanics.com/science/energy/a35382007/biden-nuclear-energy-plan/.

85. Sonal Patel, *DOE Rolls out Nuclear Innovation 'Blueprint' ahead of Biden Administration Takeover*, POWER (Jan. 13, 2021), https://www.powermag.com/doe-rolls-out-nuclear-innovation-blueprint-ahead-of-biden-administration-takeover; *see also*, Joseph Biden, *Paris Climate Agreement*, THE WHITE HOUSE (Jan. 20, 2021), https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/20/paris-climate-agreement/.

available. The determination of America's fate regarding nuclear power largely depends on the Biden administration's achievements prior to the 2022 midterm and 2024 Presidential elections.

B. China

China has recently committed to ramping up reactor production and increasing its reliance on nuclear power in the coming decades. This should not discount China's current output with them being the third largest global producer at ten percent of the global nuclear power generated.[86] Based on its most recent Five-Year Plan from 2016, China plans to decrease its current carbon footprint to a net-zero by 2060.[87] It can only accomplish this by cutting back on its major reliance on coal. China is already a global leader in solar power and will supplement its goals via wind and nuclear.[88]

The primary driving force for this change is the increased pollutions level in China and impending global CO2 emission requirements looming.[89] China currently relies on coal to supply sixty-six percent of its energy, which, combined with its massive industrial manufacturing base, makes it the largest CO2 emitter in the world.[90] China is currently operating forty-eight reactors and plan to increase the production and approval rapidly, with a commitment to make nuclear power "the new foundation of its power-generation system."[91] Nuclear power only accounts for about three percent of the Energy Sector currently, placing these lofty goals in danger of falling drastically short.[92]

The Chinese government's implementation of these plans has not been entirely smooth sailing with public approval. There are isolated incidents of residents protesting the building or development of nuclear facilities with

86. *China's nuclear power output jumps 18% year on year*, WORLD NUCLEAR NEWS (Feb. 24, 2020), https://www.world-nuclear-news.org/Articles/Chinas-nuclear-generating-capacity-continued-to-gr.

87. Katherine Koleski, *The 13th Five-Year Plan*, U.S.-CHINA ECON. AND SEC. REV. COMM'N (Feb. 14, 2017), https://www.uscc.gov/sites/default/files/Research/The%2013th%20Five-Year%20Plan_Final_2.14.17_Updated%20(002).pdf.

88. Tim McDonnell, *China is rapidly becoming the leading Nuclear Energy Superpower*, QUARTZ (Sep. 30, 2020), https://qz.com/1910492/chinas-carbon-pledge-hinges-on-a-buildout-of-nuclear-power/.

89. *Nuclear Power in China*, WORLD NUCLEAR ASS'N, (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx.

90. *Id.*

91. *Id.*

92. *Id.*

even fewer of these protests being successful.[93] The implementation of Chinese Energy policies is done in a state-controlled method with investment opportunities offered for certain groups. This can create disputes amongst the local populace and the government's placement decisions on nuclear facility locations.

Unfortunately, no reliable polling data exists on the approval of Chinese citizens regarding nuclear power, not including the protests and demonstrations. But that does not mean they are uninformed on the goings on of their government's nuclear program. The MEE (Ministry of Ecology and Environment) and the NNSA (National Nuclear Safety Administration) provide regular updates to the citizens regarding developments,[94] such as information regarding newly approved plans, updates to current facilities, emergency preparedness plans, and other useful information.[95] While they are unable to effectively voice their opposition to certain plants, the citizens are at least made aware and warned of upcoming developments.

The Chinese government did not have an assessable reaction to the accidents at Three Mile Island and Chernobyl. The first Chinese nuclear power plant was only connected into the power grid in 1991, five years after the Chernobyl accidents and twelve years after Three Mile Island.[96] Any information about the public perception or government reception is unavailable. While these accidents realistically caused internal reaction, they are inapplicable in this case, excluding Fukushima.

Following the Fukushima Daiichi accident, the Chinese government implemented a hard freeze on nuclear plant approvals for a certain period.[97] Following an extensive review of its nuclear safety programs, the country began to implement substantial changes in safety protocols for its nuclear sector. They implemented all IAEA safety standards, increased domestic

---

93. Calum MacLeod, *Protestors win Environmental battle in China*, USA TODAY (Jul. 2016, 2013), https://www.usatoday.com/story/news/world/2013/07/15/china-evironment-protest/2518221/; *see also* Li Jing, *Nuclear Fuel Plant on hold in Eastern China after thousands protest*, S. CHINA MORNING NEWS (Aug. 10, 2016), https://www.scmp.com/news/china/policies-politics/article/2001726/nuclear-plant-scheme-halted-eastern-china-after

94. *Country Nuclear Power Profiles – China*, INT'L ATOMIC ENERGY AGENCY (2020), https://cnpp.iaea.org/countryprofiles/China/China.htm.

95. *Id.*

96. Daogang Lu, *The Current Status of Chinese Nuclear Power Industry and its Future*, E-JOURNAL OF ADVANCED MAINT. (Oct. 22, 2006), http://www.jsm.or.jp/ejam/Vol.2.No.1/GA/12/article.html.

97. Jacqueline CK Lam, *China's Response to Nuclear Safety Post-Fukushima: Genuine or Rhetoric?*, UNIV. OF CAMBRIDGE – ENERGY POLICE RSCH. GROUP (Nov. 2018), https://www.eprg.group.cam.ac.uk/wp-content/uploads/2018/11/1834-Text.pdf.

and international transparency, and set realistic implementation goals on regulation standards.[98] China has an excellent record on nuclear safety with no incidents rising above an INES Level 2 incident, with its internal goal that nothing above a Level 3 ever occurs.[99] There are no external indications any accidents on this scale have occurred even with a tightly controlled state media.

The ability to act without succumbing to societal pressures is one advantage of this system of government. This does not mean the massive, planned transition from a majority coal-backed energy sector will be easy but the control the CCP wields makes it much more attainable. While there are valid criticisms of the controlling party their response to carbon control seems, on its face, an effective use of state power.

Along with their lofty goals of increased internal usage the Chinese government has ambitions to become one of the leaders in exporting nuclear technology on a global scale. Much like any established global market, it is increasingly difficult to break into one as highly regulated as nuclear power. China's primary issue is combatting the influence of its neighbor, Russia. Russia, as discussed below, is a massive exporter of nuclear technology and has a stranglehold on certain areas of the globe with developing nuclear power programs.[100] Another major issue China must navigate is its lack of membership in the International Atomic Energy Agency's Vienna Convention on Civil Liability for Nuclear Damage treaty, of which Russia is a signatory member.[101] Member States receive beneficial treatment on negotiations and establish international protocol on a large swath of policy decisions. Finally, China does not take back the spent fuel of new foreign nuclear programs they export to, a common request by fledgling programs, something to which Russia is committed to.[102] Regardless, China has set lofty goals of having at least thirty Chinese reactors built in foreign countries by 2030 as a part of its purported Five-Year Plan.[103]

With the continued rise of Chinese industry and power as the third global hegemon state we will see an increase in need for power production. This

98. *Id.*

99. *Nuclear Power in China*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

100. *Id.*

101. *Id.*

102. *Id.*

103. *Country Nuclear Power Profiles – China*, IAEA (2020), https://cnpp.iaea.org/countryprofiles/China/China.htm.

assessment does not even include China's status as the largest population in the world. The Chinese government remains committed to the increase of carbon-neutral energy creation, but the transition from fossil fuels to cleaner alternatives is not always smooth. China's commitment to becoming carbon-neutral will directly track with its success in increasing its reliance on nuclear power.

C. Russia

The resurgence of the Russian nuclear sector is surreal. During its reign as the U.S.S.R., it indirectly oversaw the world's most catastrophic and notorious nuclear accident in the world, Chernobyl. While this did have a stagnating effect on its nuclear policies, it did not prevent Russia from returning to its place as a nuclear superpower, and a major player in fledgling nuclear programs around the world. This ability to export is furthered by Russia's cutting-edge research regarding new reactor technology, in which it is the global leader.

Russia's reliance on nuclear power is like the United States in total percentage accounted for, but on a smaller scale with over nineteen percent of its total power generation relying on nuclear power but production of only around one quarter of what the United States produces.[104] This is accomplished through its operation of thirty-eight reactors almost exclusively operating in South-Western Russia, where the majority of the population lives.[105]

Russia's reactions to the Big Three is a story of maximums and minimums in how it altered its established plans. There is no quantifiable evidence the accident at Three Mile Island accident influenced Russian policy—at least none publicly available. Especially since the accident occurred during the Cold War, meaning Russia was extremely reluctant to react to American failures other than by a showing that its own program was rock-solid. The reaction to Chernobyl was much different because the U.S.S.R (Russia) was still the governing state of Ukraine. Following Chernobyl, the Russian nuclear program came to a full stop with no new

104. *Nuclear Power in Russia*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx. *See also Nuclear Power in the World Today*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx.

105. *Nuclear Power in Russia*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.

reactors beginning construction until 2006.[106] As noted above, the dissolution of the U.S.S.R., exacerbated by the accident, played a major role in destabilizing the Russian nuclear program. The program began its return to prominence and continued ramping up until the accident at Fukushima Daiichi in 2011. Then Prime Minister, now President, Vladimir Putin ordered the full stop of development and research until an extensive safety check occurred on all operating and planned reactors.[107] These reviews found nothing more than minor updates and modifications to make which the State easily implemented.[108] The Russian industry continued to expand and along with this their ambitions for their program locally and abroad.

Compared to China's ambitious plans for export Russia's confirmed plans dwarf the current Chinese proposals. Russia currently has thirty-nine reactors either under construction or confirmed for construction overseas, not including some presently under negotiation.[109] China has less than twenty reactors planned for exportation and the United States only has two.[110] A substantial portion under negotiation for Russia are those within developing nations throughout Africa.[111] This is not only an attempt to create wealth for Russia, but to further expand its influence in the region while boxing China out.

There is a variety of reasons Russia can export at the low-cost and high-volume it currently exports at. Firstly, all its programs are state-controlled and backed, providing lower costs for investment and higher levels of liability available.[112] Secondly, it is the leading nation on 'fast neutron' reactor technology, which is an innovative type of reactor with increased efficiency, lower costs, and lowered risks.[113] Finally, it has been able to supplement their industries via its oil exports and production, much to the

106. *Country Nuclear Power Profiles – Russia*, IAEA (2020), https://cnpp.iaea.org/countryprofiles/Russia/Russia.htm.

107. *Nuclear Power in Russia*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.

108. *Id.*

109. *Russia leads the world at nuclear-reactor exports*, THE ECONOMIST (Aug. 7, 2018), https://www.economist.com/graphic-detail/2018/08/07/russia-leads-the-world-at-nuclear-reactor-exports.

110. *Id.*

111. Kate Hairsine, *Russia's nuclear play for power in Africa*, DW (Mar. 6, 2020), https://www.dw.com/en/russias-nuclear-play-for-power-in-africa/a-54004039.

112. *Nuclear Power in Russia*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.

113. *Id.*

chagrin of OPEC, which has caused significant issues during the global downturn of oil prices in the Covid-19 era.[114]

The support of nuclear power in Russia is overwhelming and continues to grow. Around seventy-four percent of Russians support nuclear power and at around fifty percent see it as a viable green energy solution.[115] The populace currently wants the government to maintain and continue to develop the Russian nuclear program, despite their previous mishandlings and lack of transparency.[116] Similar to China, there are questions of the amount of governmental control on population viewpoints. This tight consolidation of national power also allows for the rapid development and growth of the sector, even if these purported numbers are inaccurate.

Russia and the United States, and more recently China, have long competed to be the reigning global superpower in the post-World War Two global community. This competition has carried over into every conceivable area of the globe ranging from the culture wars of their ideologies to the Space Race. Russia's goals of becoming the leading superpower on nuclear power are not unrealistic and are likely to occur unless China or the United States commits to overtaking them. While Russia is currently on the outs with the United Nations, it is still one of reigning superpowers and its ability to influence the global economy will be massively important as time goes on. With the combination of their cheap and readily available reactor technology, oil production influence, and continued development of overseas projects it is likely Russia will become the premier nuclear power.

D. Japan

The inclusion of Japan in the "Opt-In" section is rather surprising. Despite Japan being the only country to experience the catastrophic effects of nuclear warfare, it readily accepted and integrated nuclear power into its electrical program post World War Two.[117] "Japan" being the United States-controlled Japanese government under a United States-led

114. *OPEC: Russia rejects cut in oil production despite coronavirus impact on prices*, DW (Jun. 6, 2020), https://www.dw.com/en/opec-russia-rejects-cut-in-oil-production-despite-coronavirus-impact-on-prices/html.

115. Charles Digges, *Nuclear Power Wildly Popular in Russia, Independent Poll Shows*, BELLONA (Apr. 10, 2018), https://bellona.org/news/nuclear-issues/2018-04-nuclear-power-wildly-popular-in-russian-independent-poll-shows.

116. *Id.*

117. *Country Nuclear Power Profiles – Japan*, IEAE (2020), https://cnpp.iaea.org/countryprofiles/Japan/Japan.htm.

propaganda effort to lower the ire of Japanese citizens regarding nuclear power,[118] culminating in the Japanese government passing its first Atomic Energy bill in the 1950s and officially beginning its programs.[119] These programs were unfettered by the Three Mile Island and Chernobyl accidents, but public trust eroded after the government attempted to downplay the impacts and severity of accidents that occurred within the country.[120] The Japanese commitment to becoming self-sustainable in the energy sector, with a preference to their nuclear program, created a system with lofty expectations to succeed with inherently high risks.

For much of its history, Japan was a self-sustaining nation with a strong isolationist policy until the modern industrial period began, bringing with it increasing external/internal pressures to change and increasing reliance on imports.[121] As a small island nation, Japan had a natural shortage of minerals and resources and, over time, became increasingly reliant on foreign oil, such as the US and Russia prior to World War Two and the Middle East more recently.[122] Following the oil shock in 1974, Japan began to reinvigorate its nuclear program due to unstable and rising costs of oil.[123] This shift was unsuccessful, and Japan still relies on imports for over ninety percent of its energy needs.[124] The original plan would have solved the deficit with a nuclear renaissance, but the Fukushima Daiichi temporarily derailed that plan.

The reaction to the Fukushima Daiichi accident was swift and severe by not only the government of Japan, but also its citizens. Initially the government ordered a full stop on all nuclear power plant operation until extensive safety measures were reviewed and installed with all reactors being offline by May 2012.[125] The reactivation process of plants was costly

---

118. Eric Johnston, *Key Players got nuclear Ball rolling*, The Japan Times (Jul. 16, 2011), https://www.japantimes.co.jp/news/2011/07/16/national/key-players-got-nuclear-ball-rolling/.

119. *Id.*

120. Benjamin Sovacool, *A Critical Evaluation of Nuclear Power and Renewable Electricity in Asia*, 40 J. of Contemp. Asia, 380 (Aug. 2010).

121. Robert Hellyer, *Defining Engagement: Japan and global contexts*, 326 Harvard E. Asian Monographs (2009).

122. *Nuclear Power in Japan*, WORLD NUCLEAR ASS'N (Sep. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-power.aspx.

123. *Id.*

124. *Id.*

125. David Batty, *Japan Shuts down last working Nuclear Reactor*, THE GUARDIAN (May 5, 2012), https://www.theguardian.com/world/2012/may/05/japan-shuts-down-last-nuclear-reactor.

and required extensive international and local collaboration to update safety standards, with many of the reactors deemed too high risk to reactivate.

The approval of nuclear power in Japan took a large swing post-Fukushima Daiichi with massive changes in public opinion on whether to increase, maintain, or discontinue. The increase or maintain group dropped from around fifty percent to around twenty-two percent.[126] The decrease or abolish group grew from forty and fifteen percent to fifty-three and twenty percent, respectively.[127] Recently there has been a swing in public opinion with slight increases in approval and decreases in disapproval and abolishment.[128]

Following the accident, the public had a large outcry and engaged in countless protests and movements to either delay the building of new reactors, review the current operational ones, and/or abolish the use of nuclear power all together.[129] Many of these protests and the Fukushima Daiichi accident stirred up old sentiments surrounding anti-nuclear weapon proliferation thus bolstering the movement.[130] These protests maintained a strong presence for the following years with large movements planned on the anniversary of the accident every year with them receiving large support from Japanese celebrities and figures.[131]

Currently nuclear power accounts for only three percent of Japan's total electrical grid, which is a far cry from thirty percent in 2011.[132] Prior to the Fukushima Daiichi accident Japan was operating fifty-four reactors, compared to thirty-three now after twenty-one were deemed too risky to

126. *Nuclear Power in Japan*, WORLD NUCLEAR ASS'N (Sep. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-power.aspx.

127. *Id.*

128. Kaoru Ohno*, Japanese Opinion Poll Finds that Views on Nuclear Power Turn Slightly positive*, JAPAN ATOMIC INDUS. FORUM (Mar. 25, 2020), https://www.jaif.or.jp/en/japanese-opinion-poll-finds-that-views-on-nuclear-power-turn-slightly-positive/.

129. Krista Mahr, *What Does Fukushima's Level 7 Status mean?*, TIME (Apr. 11, 2011), https://science.time.com/2011/04/11/what-does-fukushima%E2%80%99s-new-%E2%80%9Clevel-7%E2%80%9D-status-mean/. *See also*, *Antinuclear protest held across Japan on anniversary of disaster*, MAINICHI DAILY NEWS (Mar. 12, 2012), https://web.archive.org/web/20120312172051/http://mdn.mainichi.jp/mdnnews/news/20120312p2g00m0dm069000c.html.

130. *Plutonium and Mickey Mouse*, THE ECONOMIST (Mar. 31, 2011), https://www.economist.com/asia/2011/03/31/plutonium-and-mickey-mouse

131. Noriko Manabe, *Music in Japanese Antinuclear Demonstrations*, THE ASIA-PACIFIC J. (Oct. 18, 2013), https://apjjf.org/2013/11/42/Noriko-Manabe/4015/article.html

132. *Japan's Nuclear Power Plants*, NIPPON (Mar. 10, 2020), https://www.nippon.com/en/features/h00238/japan%E2%80%99s-nuclear-power-plants.html.

restart.[133] Prior to 2011 the Japanese National Diet (their legislative body) had a goal of Nuclear Power providing at least forty percent of the electrical grid by 2017.[134] That number has since been adjusted to twenty percent by 2030, a major setback in its long-established plans.[135] Currently Japan has two other reactors under construction with plans for additional reactors in the near future.[136]

Despite the occurrence at Fukushima Daiichi the Japanese government remains committed to the restoration and increase of their nuclear power capabilities. This is an absolute necessity in a country that relies almost exclusively on imports for their energy needs. Currently it intends to increase not only its nuclear operations, but also increase renewables and lower fossil fuel use overall.[137] A major focus going forward is redoing their energy sector to comply with the Paris accords with a major focus on lowering CO^2 emissions.[138] Japan's struggle to gain and maintain energy independence is an important situation to monitor in the coming decades.

E. Ukraine

Ukraine is one of the most surprising supporters of nuclear energy in the opt-in section due it being the site of the Chernobyl accident. The Chernobyl accident, as discussed above, is the most notorious nuclear disaster ever. Regardless, the government of Ukraine has been committed to and further solidified its support of nuclear power in Ukraine for the near future. Even as far as its current President Volodomyr Zelensky aiming to become the leader in nuclear power in Europe and abroad.[139] Despite all that has occurred, the country has remained committed to a strong nuclear power program to this day.

Ukraine's use of nuclear power is nothing short of prolific in comparison to all but two countries (France and Slovakia), not including the monolith

133. *Id.*
134. *Id.*
135. *Id.*
136. *Id.*
137. Steve Kidd, *Japan – Is there a future in nuclear?*, NUCLEAR ENG'G INT'L (Jul. 4, 2018), https://www.neimagazine.com/opinion/opinionjapan-is-there-a-future-in-nuclear-6231610/.
138. Ken Silverstein, *Japan Circling Back to Nuclear Power After Fukushima Disaster*, FORBES (Sep. 8, 2017), https://www.forbes.com/sites/kensilverstein/2017/09/08/japan-may-be-coming-full-circle-after-its-fukushima-nuclear-energy-disaster/?sh=1ae20a7230e8.
139. Charles Digges, *Ukraine's President embraces nuclear energy while relying on elderly reactors*, BELLONA (Oct. 7, 2020), https://bellona.org/news/nuclear-issues/2020-10-ukraines-president-embraces-nuclear-energy-while-relying-on-elderly-reactors.

of the United States. Currently, nuclear power generates over half of Ukraine's electricity (Slovakia is around the same and France is near seventy percent).[140] Ukraine accomplishes this level of production via fifteen nuclear reactors. Unfortunately, most of them are older generation Soviet-era models which will need to be replaced or updated.[141] This does not prevent them from being effective with Ukraine generating the seventh largest amount of electricity via nuclear power.[142] While Ukraine is clearly a much smaller country than most of the other main nuclear powers, it is still an important player in the international system.

While general polling about the popularity of nuclear power in Ukraine is unavailable, it is reasonable to infer there will always be a lingering opposition or at least unease by the general populace. One section that unsurprisingly supports further development is the nuclear power workers themselves. While this is a self-serving interest it is important to note they have not only advocated for continued reliance but further development and research of future reactors and technology[143] Going so far as to enter into general strikes and other methods to force the government's hand on transparency and future plans.[144]

One of Ukraine's main goals in maintaining and increasing their nuclear capacity is to free itself from energy reliance on the then U.S.S.R. and now Russian Federation. During its days as a substate and into the late 2000s, it received all nuclear reactor technology and fuel from the U.S.S.R.[145] Ukraine now receives an increased amount from foreign companies with goals to have at least thirty percent supplied from outside sources.[146] It plans on further increases in non-Russian imports with plans for being able

140. *Nuclear Share of Electricity Generation in 2019*, IAEA – POWER REACTOR INFO. SYSTEM (Nov. 14, 2020), https://pris.iaea.org/PRIS/WorldStatistics/NuclearShareofElectricityGeneration.aspx.

141. *Nuclear Power in Ukraine*, WORLD NUCLEAR ASS'N (Nov. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/ukraine.aspx#:~:text=Ukraine%20is%20heavily%20dependent%20on,commissioned%20two%20large%20new%20reactors.

142. *Id.*

143. *Nuclear workers protest in Ukraine*, IND'L-UNION (Dec. 5, 2019), http://www.industriall-union.org/nuclear-workers-protest-in-ukraine-0.

144. *Id.*

145. Artem Belousov, *Westinghouse CEO: We are ready to put our fuel in all of Ukraine's NPPs*, UNIAN (Oct. 28, 2015), https://www.unian.info/economics/1166817-westinghouse-ceo-we-are-ready-to-put-our-fuel-in-all-of-ukraines-npps.html.

146. *Ukraine signs new fuel contract with Westinghouse*, NUCLEAR ENG'G INT'L (Feb. 1, 2018), https://www.neimagazine.com/news/newsukraine-signs-new-fuel-contract-with-westinghouse-6043909.

to do more enrichment and treatment processes within the state in the coming decade.[147] This is in combination with its goals to decrease reliance on imported coal as a large swath of their electricity sector. Recently, the Ukrainian government has reaffirmed goals to increase its nuclear power output to 29.5 GWe by 2030.[148] This is in comparison to its current output of 13.8 GWe, a more than double increase of current levels.[149] Additionally, it hopes to have renewables make up forty percent of its grid by 2030 also.[150] Ukraine has a totally unique opportunity upon the international stage. They could, much like the fabled Phoenix, rise from the ashes of Chernobyl and become the leading global power on small state nuclear power.

G. India

The history of India's nuclear program is one steeped in the European hegemony and a nation with a history of resourcefulness. India was one of the earliest integrators of nuclear energy beginning immediately after the conclusion of World War Two. After a few years of fledgling research, a large push was made with the introduction of the Atomic Energy Bill in 1948.[151] Yet, India has had to forge their own path and develop a system of self-reliance regarding nuclear power since they have refused to enter into the Nuclear Non-Proliferation Treaty.[152]

Due to India's outside looking in of nuclear power research and access to fuel its power grid capabilities have lagged behind what it is capable of producing. Currently India is producing only around three percent of their total electrical output from nuclear power despite being in the top fifteen of nuclear power produced globally.[153] India plans to decrease its massive reliance on foreign power imports due to an estimated 156% predicted

147. *Nuclear Power in Ukraine*, WORLD NUCLEAR ASS'N (Updated November 2020) https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/ukraine.aspx#:~:text=Ukraine%20is%20heavily%20dependent%20on,commissioned%20two%20large%20new%20reactors.

148. *Id.*

149. *Id.*

150. *Id.*

151. M. V. Ramana, *Nuclear Power in India: Failed Past, Dubious Future*, NPEC (Aug. 20, 2006) http://npolicy.org/article.php?aid=333&rid=6

152. *India – Nuclear*, NUCLEAR THREAT INITIATIVE (Updated Nov. 2019) https://www.nti.org/learn/countries/india/nuclear/

153. *Nuclear Power in India*, WORLD NUCLEAR ASS'N (January 2021), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.

increase in demand for electricity by 2040.[154] This goal will be supplemented by an increase of its nuclear capacity from around three percent to nine percent within the next twenty-five years.[155] India continues to set massive construction goals with seven new reactors under construction that would nearly double their current output.[156]

Despite these ambitious goals not all members of Indian society are on board. There have been a slew of protests and movements to stop the development and construction of nuclear facilities around the nation.[157] These protests have been highly effective, causing many of the planned constructions to be delayed, moved, or altogether abandoned.[158] The majority of these protests stemmed from lasting sentiments about the Chernobyl accident with the fears being accelerated by the Fukushima Daiichi accident.[159] These protests are focused on reforming and improving the safety regulations around the Indian nuclear program with fears of similar accidents occurring.[160] A public interest group even went as far as filing a suit against the Indian government in the Supreme Court asking for a stay on all proposed plants until increased safety measures had been taken.[161] The Court declined to take the case due to a lack of expertise on nuclear field and lack of ability to direct the government on the issue.[162]

India's self-reliance has stemmed from its lack of inclusion in the international nuclear trade due to its refusal to enter into the Nuclear Non-Proliferation Treaty fifty years ago, thus causing a lag in outside technological help and resources.[163] India had developed its nuclear weapons program before the signing but had not detonated tests prior to

---

154. *Id.*

155. *Id.*

156. *Id.*

157. Ranji Devraj, *Prospects Dim for India's Nuclear Power Expansion as Grassroots Uprising Spreads*, (Oct. 25, 2011), https://insideclimatenews.org/news/25102011/india-nuclear-energy-expansion-grassroots-uprising-jaitapur-maharashtra-tamil-nadu-west-bengal-fukushima/.

158. *Id.*

159. Siddarth Srivastava, *India's Rising Nuclear Safety Concerns*, ASIA SENTINEL (Oct. 27, 2011), https://www.asiasentinel.com/p/indias-rising-nuclear-safety-concerns.

160. *Id.*

161. Ranji Devraj, *Prospects Dim for India's Nuclear Power Expansion as Grassroots Uprising Spreads*, (Oct. 25, 2011), https://insideclimatenews.org/news/25102011/india-nuclear-energy-expansion-grassroots-uprising-jaitapur-maharashtra-tamil-nadu-west-bengal-fukushima/.

162. *Id.*

163. *India, China & NPT*, WORLD NUCLEAR ASS'N (Dec. 2016), https://www.world-nuclear.org/information-library/safety-and-security/non-proliferation/india,-china-npt.aspx.

1970, only detonating in 1974.[164] India was previously invited to the treaty but refused on principle.[165] It believed the treaty created a system of haves and have-nots while also preventing India from keeping its own deterrence in place.[166] A primary factor in its refusal was distrust of both neighboring China, already been accepted in the treaty process, and now Pakistan.[167]

This refusal had drastic impacts on the nuclear industry in India since it banned them from trading in fuel resources and technology exchanges with other nations.[168] This forced India to use alternative fuel sources, such as Thorium and imported Uranium (from non-treaty countries) when possible, a practice it continues today.[169] Recently, the international community has allowed India to enter into select markets for resources and allows for continued development of its programs.[170]

Ironically, for a country entirely outside the international regulatory industry, India has had little to deal with regarding internal monitoring of their reactors. Outside of the protests mentioned above, there was no large reaction among the Indian nuclear power industry to any of the Big 3. The largest reaction occurred post-Fukushima Daiichi where the government created a task force to inspect the safety standards of its nuclear fleet.[171] The task force found minor fixes that were all handled within the next few years. Additionally, the Indian government established two specialized regulatory agencies in response to the accident and its inclusion in trade/research agreements: the Council of Nuclear Safety, monitoring internally, and the Nuclear Safety Regulatory Authority, an outside agency.[172]

India faces two unique challenges regarding nuclear power. First, it is still a country on the outside with regard to international acceptance; second, it has the second-largest population which is still growing at an unprecedented rate. This growing population will only require increased energy as the poverty levels in India continue to decrease and more technology and manufacturing infrastructure is installed. India will have to

164. *Id.*
165. *Id.*
166. *Id.*
167. *Id.*
168. *Id.*
169. *Nuclear Power in India,* WORLD NUCLEAR ASS'N (Jul. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.
170. *Id.*
171. *Id.*
172. *Id.*

maintain, and realistically increase, its planned nuclear output to be able to keep pace with their population's needs. The story of India accomplishing these goals will largely follow the success of its nuclear power program.

VI. Opt-Out Countries

This section focuses on countries that have chosen to "opt-out" to increasing or maintaining their reliance on nuclear power, instead choosing to slowly wean off of or fully shutdown their current systems for various political, environmental, or other reasons. These are not the only countries that have chosen this path, as many smaller countries are following suit. This is a small sample examining larger countries and/or countries with unique stances on nuclear power.

A. Germany

The history of nuclear power in Germany is one of shifting allegiances and swift, exacting, alterations to current objectives. The machine-like efficiency of German industry extends into the policy making decisions of its Chancellors and Bundestag (Federal Diet). Germany's plan for decommissioning also follows this theory with its decommissioning goals set to occur at a blistering pace. Compared to most countries whose decommissioning target goals are decades removed from the current date. This is even more impressive since the act of decommissioning and replacing the lost power capacity takes years of planning and structure. The issue for Germany is the fast-approaching cliff of replacing the power generation while maintaining inexpensive energy costs.

Prior to the Fukushima Daiichi accident Germany was receiving over twenty-five percent of its energy capacity from its seventeen operating nuclear reactors.[173] Which is an enormous amount compared to the current amount of twelve percent from seven operating reactors.[174] Germany plans to fill this massive power creation vacuum with increased research and development of renewable sources with middling results so far. Germany has temporarily increased its reliance on imported coal, specifically Lignite, the most toxic coal currently in use.[175] Coal currently supplies Germany

173. *Nuclear Power in Germany*, WORLD NUCLEAR ASS'N (Dec. 2019). https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx.

174. *Id.*

175. Genon K. Jensen, *Lignite Coal – health effects and recommendations from the health sector*, HEAL (Dec. 2018), https://www.env-health.org/wp-content/uploads/2018/12/HEAL-Lignite-Briefing-en_web.pdf.

with forty percent of its energy needs with half of that being Lignite, specifically.[176]

The history of nuclear power in Germany is a two-part story since, following World War II, the "Germany" we recognize today was divided among the United States and the then-U.S.S.R. as Western and Eastern Germany. Thus, both countries implemented and pushed their own nuclear agendas though these policies aligned upon reunification in 1990. The driving force of Germany's nuclear revolution was, just like France, the oil shock of 1974.[177] The German people strongly supported the ramping up of nuclear power to establish energy independence and to lower consumer costs.[178] This policy abruptly changed following the accident at Chernobyl with both Eastern and Western Germany committing to a halt on reactor commissioning, with the final project finishing in 1989.[179] Following the reunification of the two countries in 1990, Germany decommissioned all previously in-use Soviet-technology reactors within the Eastern section.[180] This anti-nuclear sentiment carried over into the 2000s and beyond.

The first attempt at decommissioning occurred in the early 2000s with two power plants being turned off and full nuclear fleet shutdown goals set for the late 2010s to early 2020s.[181] As rising concerns of Germany's ability to adequately replace the nuclear power output continued, the shutdowns were renegotiated in 2010.[182] These negotiations shifted the goalposts all the way into the mid-2030s, a nearly 20-year extension to plans.[183] The government at that time implemented several new layers of taxation regarding nuclear power causing the offsetting cost to be eaten by the companies and not the consumers.[184]

As is true of all of man's "best laid plans," the 2010 negotiations immediately became moot following the 2011 Fukushima Daiichi accident.

---

176. *Nuclear Power in Germany*, WORLD NUCLEAR ASS'N (Dec. 2019), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx.

177. *Id.*

178. *Id.*

179. *Id.*

180. *Id.*

181. Wolfgang Renneburg, *Nuclear Phase-out in Germany and the Challenges for Nuclear Regulation*, FMENCNS (May 24, 2001), https://web.archive.org/web/20050520081034/http://www.bmu.de/english/nuclear_safety/doc/3420.php.

182. *Nuclear Power in Germany*, WORLD NUCLEAR ASS'N (Dec. 2019), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx.

183. *Id.*

184. *Id.*

This caused a complete stop on German nuclear power and was a death blow. Chancellor Angela Merkel, a long-time proponent of nuclear power, completely flipped sides in response to polling pressure and public beliefs.[185] Immediately after the accident, Merkel placed a three-month moratorium on the 2010 negotiation decisions and temporarily shut down 8 of the 17 reactors in operation, all made prior to 1981.[186] Upon review, Merkel approved the shutdown of all reactors by 2022.[187] With then Environment Minister Norbert Rottgen quoted as "there will be no clause for revision."[188] Germany is currently on track to meet these shutdown goals and there is no indication of a sudden change in policy.

As discussed above, the anti-nuclear movement has been a strong presence within the German political sphere for the entirety of nuclear power's existence.[189] The country's first major protest prevented the construction of a reactor in the hamlet of Wyhl and thus began the long-standing opposition within German culture.[190] These protests continued along with massive rallies in response to the Chernobyl and Fukushima Daiichi accidents, the latter creating a 200,000-person strong demonstration on the eve of the decommissioning vote.[191] Predictably, the anti-nuclear sentiment is strong among the German populace with seventy-three percent agreeing the phase out was the correct choice based on a 2012 poll.[192] These sentiments held true in 2019 with seventy-four percent agreeing the phase-out was the correct choice.[193]

The abrupt change in nuclear policy has left the German people and industry holding the bag regarding health and rising costs. The costs of transitioning to renewables without the needed infrastructure has required

185. Andrew Bowen, *Nuclear Backlash forces Merkel to rethink energy policy*, DW (Mar. 14, 2011), https://www.dw.com/en/nuclear-backlash-forces-merkel-to-rethink-energy-policy/a-14909851.

186. *Germany: Nuclear Power plants to close by 2022*, BBC (May 30, 2011), https://www.bbc.com/news/world-europe-13592208.

187. *Id.*

188. *Id.*

189. *Id.*

190. *Id.*

191. Judy Dempsey, *Merkel Loses Key German State on Nuclear Fears*, N.Y. TIMES (Mar. 27, 2011), https://www.nytimes.com/2011/03/28/world/europe/28germany.html?_r=1.

192. *Nuclear Power in Germany*, WORLD NUCLEAR ASS'N (Dec. 2019), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx.

193. Benjamin Wehrmann, Julian Wettengel, *Polls Reveal Citizens' support for Energiewende*, JOURNALISM FOR THE ENERGY TRANSITION (Oct. 21, 2019), https://www.cleanenergywire.org/factsheets/polls-reveal-citizens-support-energiewende.

Germany to increase its importation of non-renewables as a temporary fix. Germany is currently one of the largest importers of fossil fuels to combat the drop in energy capacity.[194] Additionally, Germany has filled in the cost gap by dramatically increasing the taxation costs on energy. Germany has one of the lowest wholesale energy costs in Europe, but some of the highest retail prices due to high percentage taxes on all energy forms.[195]

This does not factor in the environmental and health hazards that have arisen due to the sudden spike in fossil fuel usage in Germany. Germany is currently the largest CO2 producer in Europe with major increases in carbon emissions and linkable deaths each year.[196] These deaths and environmental damage could have been mitigated if nuclear had been used as a bridge to a fully renewable energy cycle instead of a fossil-fuel band aid.[197] Germany has rapidly accelerated its decommissioning and will realistically achieve its set goals. The evergreen question will be if this was the correct decision in the long run.

B. France

When comparing nuclear powers there is none more colossal than France in terms of shares of nuclear power. France currently operates at the highest rate with around seventy-five percent of its electricity coming from nuclear power.[198] However, they are only second in overall energy production via nuclear power producing a little less than half of what the United States produces, 382.4 Gigawatts compared to 809.36 Gigawatts.[199] They operate the second-largest number of reactors, with fifty-eight reactors currently

194. *Nuclear Power in Germany*, WORLD NUCLEAR ASS'N (Dec. 2019), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx.

195. *Id.*

196. Daniel Oberhaug, *Germany Rejected Nuclear Power-and Deadly Emissions Spiked*, (Jan. 23, 2020), https://www.wired.com/story/germany-rejected-nuclear-power-and-deadly-emissions-spiked/.

197. Nathanael Johnson, *The cost of Germany turning off nuclear power: Thousands of lives*, GRIST (Jan. 8, 2020), https://grist.org/energy/the-cost-of-germany-going-off-nuclear-power-thousands-of-lives/.

198. *Nuclear Power in France*, WORLD NUCLEAR ASS'N (Sep. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx.

199. *Nuclear Share of Electricity Generation in 2019*, IAEA – POWER REACTOR INFO. SYS. (Nov. 14, 2020), https://pris.iaea.org/PRIS/WorldStatistics/NuclearShareofElectricityGeneration.aspx.

operating and additional reactors currently approved.[200] This reliance on cheaper energy sources, including other environmentally friendly ones, allows for France to be the largest net exporter of power, generating over three billion Euros annually.[201]

Despite the economic advantages and climate-friendly nature of nuclear power, its popularity has seen a large drop in recent years, including protests of its continued use. According to an Odoxa poll, disapproval of continued nuclear power use has reached a majority in France at fifty-three percent, compared to sixty-seven percent being in favor in 2013.[202] According to this poll, French citizens view nuclear power as a necessary evil rather than an asset, especially considering recent developments in other renewable sources.[203]

The anti-nuclear protest movement in France dates back to at least the 1970s. The movement has gained traction in the last decade, especially as more European Union countries commit to a ramp-down of nuclear power. Many of these protests are symbolic in nature and akin to raising awareness about the dangers of nuclear power or obstructing/delaying events,[204] though some events have been more violent in nature. For example, fifty-seven Greenpeace activists used trucks to ram through the gates of the Fessenheim Nuclear plant to hang anti-nuclear banners from its buildings as they occupied the facility.[205]

Currently France has committed to a major de-escalation of reliance on nuclear power with a current goal to go from seventy-five percent to around

200. *Nuclear Power in France*, WORLD NUCLEAR ASS'N (Sep. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx.

201. *Id.*

202. *French Public Opinion growing against Nuclear Power*, CONNEXION, (Oct. 28, 2018), https://www.connexionfrance.com/French-news/French-public-opinion-is-growing-against-nuclear-power-as-awareness-of-environment-and-renewable-energy-grows.

203. *Id.*

204. *Thousands of Protestors Obstruct Nuclear Waste Transport*, SPIEGEL (Nov. 28, 2011), https://www.spiegel.de/international/germany/radioactive-cargo-delayed-thousands-of-protesters-obstruct-nuclear-waste-transport-a-800319.html; *see also*, *Anti-nuclear demos across Europe on Fukushima anniversary*, EURONEWS (Nov. 3, 2012), https://www.euronews.com/2012/03/11/anti-nuclear-demos-across-europe-on-fukushima-anniversary (Thousands of protestors delayed the delivery of Nuclear Waste from France to Germany by blocking train tracks).

205. Reuters, *France: Greenpeace Activists Arrested in Break-In*, N.Y. TIMES (Mar. 18, 2014), https://www.nytimes.com/2014/03/19/world/europe/france-greenpeace-activists-arrested-in-break-in.html?_r=0.

fifty percent by 2035, originally set for 2025 but later deemed unrealistic.[206] The legislation also capped the production levels at its then- current levels and would not allow an increase, no matter that when under-construction reactors are finished this will force shutdowns of older reactors.[207] The anti-nuclear sentiment has always been present but has grown in power following the 2011 Fukushima Daiichi accident. The calls have centered around the safety and regulation of the aging French nuclear fleet, citing expert concerns about long-term viability and safety.[208] The movement for backing off of nuclear power has solidified its grasp on French policy and it is unlikely to change soon.

The biggest issue the French nuclear fleet faces is replacing its aging fleet while maintaining its elevated levels of production. They have the internal goal of reducing production to fifty percent over fourteen years. The primary response of the French government was the creation of Grand Carénage, an investment program to extend the lifetimes of aging reactors slated to finish in 2025.[209] Additionally, the vote on construction of new reactors has been delayed until at least 2022 following the planned completion a new reactor at the Flamanville station.[210] Ironically, this reactor construction has faced countless delays and budget overspending for nearly a decade so this goalpost may be adjusted in time.[211]

As France looks forward to the future, it has a precarious balance to strike with three major challenges arriving in the coming decades: first, the replacement of its aging fleet which will cap out around 2040; second, its carbon neutral goal set for 2050; and third, doing all of this under its current

206. *Nuclear Power in France*, World Nuclear Association (Sep. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx.

207. *Id.*

208. Matthew Dalton, *Coverup at French Nuclear Supplier Sparks Global Review*, WALL ST. J. (Dec. 13, 2016), https://www.wsj.com/articles/problems-at-nuclear-components-supplier-spark-global-reviews-1481625005.

209. *Viewpoint: A long future for France's nuclear fleet?*, WORLD NUCLEAR NEWS (Apr. 23, 2019), https://www.world-nuclear-news.org/Articles/Viewpoint-A-long-future-for-Frances-nuclear-fleet.

210. *France to decide on new nuclear build after 2022*, NUCLEAR ENG'G INT'L (Jan. 14, 2020), https://www.neimagazine.com/news/newsfrance-to-decide-on-new-nuclear-build-after-2022-7598148.

211. Reuters Staff, *Regulator unaware of fresh delays at EFD's Flamanville 3 nuclear reactor*, REUTERS (Mar. 28, 2020), https://www.reuters.com/article/france-nuclearpower/regulator-unaware-of-fresh-delays-at-edfs-flamanville-3-nuclear-reactor-id.

commitment to lowering nuclear and increasing renewables.[212] President Emmanuel Macron is a staunch advocate of maintaining and further developing the nuclear fleet, claiming the future of France goes with it.[213] The future of the European nuclear leader's policy seems to be set for a massive step back but the chances of a major shift in policy goals are still extremely high. The success of the planned transition to renewable energy sources will be the leading indicator on commitment to a plan that is approaching a steep cliff.

C. Italy

In an article comparing the relevancy of nuclear power and its policy implications, it would seem useful for the country involved to have any form of nuclear capacity. Italy currently has no operating reactors and its people have vehemently denied the option of any plans. However, they are an important comparison country when examining the impact of Chernobyl and Fukushima Daiichi on public perception. The story of Italian nuclear power is also one of exceedingly unfortunate timing with both its major referendums occurring right after government-approved change followed by a global nuclear disaster.

During its "peak" of nuclear power integration, Italy was operating four reactors and planned for a fifth reactors construction.[214] Conversely, Italy is now the only G8 country with no reactors in operation.[215] Its lack of nuclear power has had profound impacts on its energy sector, mostly in increasing costs and increased importation of energy. Italy is currently the second largest net importer of energy, mostly from France and Switzerland, accounting for around sixteen percent of its current power grid.[216] The increased reliance on imports and oil and gas—thirty nine percent of its grid—has caused the fluctuation and increase of energy prices, the highest in the European Union on average.[217]

---

212. *New nuclear will esnsure France's energy security, SFEN says*, WORLD NUCLEAR NEWS (Jul. 1, 2020) https://world-nuclear-news.org/Articles/New-nuclear-will-ensure-Frances-energy-security-SF.

213. *Macron stresses important of nuclear energy for France*, WORLD NUCLEAR NEWS (Dec. 09, 2020) https://www.world-nuclear-news.org/Articles/Macron-stresses-importance-of-nuclear-energy-for-F.

214. *Nuclear Power in Italy*, WORLD NUCLEAR ASS'N (Apr. 2018), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/italy.aspx.

215. *Id.*

216. *Id.*

217. *Italy – Country Nuclear Power Profiles*, INT'L ATOMIC ENERGY AGENCY (2020), https://cnpp.iaea.org/countryprofiles/Italy/Italy.htm.

The approval of nuclear power has swung rapidly in both directions' dependent on the populace's responses. Originally, Italy decided to implement a broad nuclear program in response to the 1974 Oil Crisis and its tenuous dependency on foreign oil.[218] The public's perception of nuclear power has soured, especially following the major accidents at Chernobyl and Fukushima Daiichi. One month prior to the Chernobyl accident, Italy had reaffirmed its belief in a strong nuclear program to offset the rising cost of energy, specifically oil.[219] Following the Chernobyl accident there was a national referendum which led to a vote in favor of dissolution of the program.[220] The Government subsequently adopted this position, and the entire nuclear fleet was shut down in time.[221]

There was a serious attempt to revive the nuclear industry in response to rising energy costs and the viability of using the already available reactors and technology.[222] The plan included an agreement with France to share nuclear expertise in reactor construction along with plans for four new nuclear stations.[223] Certain regions delayed the process by protesting the new agreement and bills within the Italian legislature, but the proposed plans continued, even after some litigation.[224] These carefully laid plans came to a screeching halt after the accident at Fukushima Daiichi.

Immediately after the accident at Fukushima Daiichi, the Italian government implemented a one-year moratorium on all nuclear power plants to assess its own safety guidelines.[225] Unfortunately, in January 2011, the opposition party had already proposed another national referendum to kill the budding nuclear revival.[226] The government held the vote in June, just months after the Fukushima Daiichi accident and during the government-imposed moratorium.[227] A truly inopportune time for an already precariously balanced nuclear policy proposal. Unsurprisingly, the

218. *Id.*

219. *Nuclear Power in Italy*, WORLD NUCLEAR ASS'N (Apr. 2018), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/italy.aspx.

220. *Id.*

221. *Id.*

222. *Italy Rejoins the nuclear family*, WORLD NUCLEAR NEWS (Jul. 10, 2009), https://www.world-nuclear-news.org/NP_Italy_rejoins_the_nuclear_family_1007091.html.

223. *Id.*

224. *Nuclear Power in Italy*, WORLD NUCLEAR ASS'N (Apr. 2018), https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/italy.aspx.

225. *Id.*

226. *Id.*

227. *Id.*

referendum passed, thus undoing all agreements and proposed legislation stemming from the revival process.[228]

The history and future of nuclear power in Italy is set in stone for the coming decades. There have been two generations of Italian citizens which have resoundingly rejected the prospect of nuclear power in the Italian energy sector. The point of focus on seeing any change in this system is on the rising cost of energy and what the people view as a breaking point. Will the Italian government stay committed to importing energy needs or develop more renewable energy sources? One pervasive issue for Italy is that the longer it waits to return, the higher the cost of reactor and regulation updating becomes, especially within the European Union.[229] The option of nuclear reactivation is always available but is highly dependent on the populace of Italy changing its opinions on it which as shown above is extremely unlikely.

D. Belgium

Belgium is one of the more important countries in comparison due to the counterintuitive actions of the government. Belgium on paper is a large supporter and major dependent of nuclear power, yet it continues to head down the path of decommissioning. One of the confounding factors is the governmental system Belgium has in place with a complex set of regional governmental branches. Nevertheless, in terms of economic sense and popular approval, its commitment to shutdowns does not make sense.

Belgium currently operates seven reactors throughout the country, providing for half of the nation's electrical grid.[230] This is a steep level of replacement that must be met with an impending commitment of full shutdown of reactors by 2025.[231] The decommissioning of the nuclear power program has had support from the Belgium government since the turn of the millennia, discussed in more detail below.[232]

These current government policies additionally go against the preference of the people. The support for nuclear power in Belgium is a super majority

228. *Id.*

229. *Nuclear Safety Directive*, ENSREG, http://www.ensreg.eu/nuclear-safety-regulation/eu-instruments/Nuclear-Safety-Directive (last visited on Jan. 6, 2021).

230. *Nuclear Power in Belgium*, WORLD NUCLEAR ASS'N (May 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/belgium.aspx.

231. *Belgium maintains Nuclear Phase-out Policy*, WORLD NUCLEAR NEWS (Apr. 4, 2018), https://www.world-nuclear-news.org/NP-Belgium-maintains-nuclear-phase-out-policy-0404184.html.

232. *Belgium – Country Nuclear Power Profiles*, INT'L ATOMIC ENERGY AGENCY (2020), https://cnpp.iaea.org/countryprofiles/Belgium/Belgium.htm.

and has continued to rise with eighty-three percent supporting it, compared to the eighty percent in 2017.[233] These numbers are high in comparison to most other nuclear power countries, but the government has chosen to forego the economic incentives and population preferences. There is concern among the populace that a full shutdown will cause a spike in energy prices and destabilization of energy security going forward.[234]

The initial phase-out proposals began in 1999, by a slim margin from a proposal on the fringe Green Party with predictions it would be overturned in the next election cycle.[235] This proved false as the implemented plan stayed on course throughout the 2000s.[236] Leading into the 2010s, the government reaffirmed its goal of shutting down at least seven reactors by 2015, but this goal was not achieved.[237] The government has repeatedly affirmed its goal of full shutdown by 2025 despite some missed checkpoints along the way.[238]

While most of the other countries in this catalog have reacted to outside forces or accidents to initiate their shut down plans, the drive for Belgium's policy was almost entirely internal. Despite a large majority of Belgian citizens supporting maintaining the nuclear program, there are a small portion that oppose it and have protested about the continued operation of the current reactors.[239] There were no major reactions to the accidents at Three Mile Island and Chernobyl that caused immediate change, but focused anti-nuclear sentiments heading into the 1990s. The accident at Fukushima Daiichi served as additional fuel for the government to maintain its current plan of decommissioning by 2025. The most vital nexus to monitor in the coming decade for Belgium will be the extension or commitment of nuclear phase-out plans as the deadlines approach. Will the

233. *Nuclear Power in Belgium*, WORLD NUCLEAR ASS'N (May 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/belgium.aspx.

234. *Id.*

235. *Belgium – Country Nuclear Power Profiles*, INT'L ATOMIC ENERGY AGENCY (2020), https://cnpp.iaea.org/countryprofiles/Belgium/Belgium.htm.

236. *Id.*

237. *Belgium Plans to phase out Nuclear Power*, BBC NEWS (Oct. 31, 2011), https://www.bbc.com/news/world-europe-15521865.

238. *Belgium Maintains Nuclear Phase-out policy,* WORLD NUCLEAR NEWS (Apr. 4, 2018), https://www.world-nuclear-news.org/NP-Belgium-maintains-nuclear-phase-out-policy-0404184.html.

239. *Anti-nuclear demos across Europe on Fukushima anniversary,* EURONEWS (Mar. 11, 2012), https://www.euronews.com/2012/03/11/anti-nuclear-demos-across-europe-on-fukushima-anniversary.

anti-nuclear sentiment remain within the government or will the need for energy independence and lower costs change the tides?

E. Switzerland

Switzerland's history regarding nuclear power is intriguing, with various factions vying for control of the future of the program throughout the history of the program's history. There have been countless protests, referendums, and movements to slow, cancel, and abolish the programs for over fifty years, yet the government long continued to rely on and improve its nuclear power program. This changed course within the past decade and Switzerland is on track for full decommissioning in the coming decades.

Switzerland currently has four reactors in operation that provide thirty-two percent of the country's electrical grid.[240] There has been a large push for a focus on making renewables an even larger super-majority of the energy providers. Currently Hydroelectricity is providing sixty percent of its electrical grid which is one of the highest percentages in the world.[241] This is an attainable goal for a nation rich with renewable energy resources and a small total population in comparison to other countries within this comparison. Currently, its population is around 8,700,000 as of 2020.[242]

The populace and certain government factions have long vied to remove nuclear power from the Energy program of Switzerland. The accidents at Chernobyl and Fukushima Daiichi were major catalysts for government action and the protests groups' movements. The accident at Three Mile Island seemed to have no major observable effects on the movement. The first three reactors in Switzerland were built without issue, though a planned reactor in a Kaiseraugst generated a massive reaction from the local populace and the nation.[243] These movements included a local occupation of the planned facility and protests around the nation, marking the first major movement of the Anti-nuclear groups in Switzerland.[244]

These sentiments increased following the disastrous accident at Chernobyl. One of the few initiatives the Swiss public have approved was a ten-year moratorium on the construction of nuclear power plants starting in

240. *Nuclear Power in Switzerland*, WORLD NUCLEAR ASS'N (July 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/switzerland/.

241. *Id.*

242. *Switzerland Population*, WORLDOMETER, https://www.worldometers.info/world-population/switzerland-population/ (last visited on Dec. 31, 2020).

243. *The Anti-Nuclear protest movement in Switzerland*, EJATLAS (Dec. 31, 2020), https://www.ejatlas.org/print/the-anti-nuclear-movement-in-switzerland.

244. *Id.*

1990.[245] There were continued efforts to ban nuclear power and further referendums or initiatives throughout the 1990s and 2000s, but they did not acquire the required votes. This changed again following the Fukushima Daiichi accident, which caused a major shift in public and governmental perceptions on nuclear power.

Immediately after the accident in Japan there were large protests of Switzerland's oldest nuclear reactor in an attempt to have it be shut down.[246] Within days of the rally, the Swiss Cabinet moved to ban the future production of new nuclear reactors and that any existing reactors could operate until the end of their lifetimes but would not replace the reactors.[247] This decision was affirmed by the Swedish people in 2017 with fifty-eight percent of the Swiss populace accepting the Energy Strategy 2050 which notably bans the building of new nuclear reactor while increasing the development of renewable energy sources.[248] This change has already led to the decommissioning of an older reactor, the Muehleberg station, which was shut down ahead of schedule due to rising maintenance costs.[249]

Switzerland's history of a constant tug-of-war regarding nuclear power policy is one that is rather unique due to the country's size and natural resources available. For the current time Switzerland's future is locked in via the 2050 Energy plan yet this could change in the coming years with one of the countless referendums or initiatives the populace is famous for.

F. Sweden

Sweden's inclusion in the opt-out section is misleading in part since it is currently planning to build a slew of new reactors to replace its aging fleet. The process by which it arrived at this change of course is what makes Sweden a categorical fit for the opt-out section. For over thirty years following 1980, Sweden banned the construction of any and all nuclear

245. *Nuclear Power in Switzerland*, WORLD NUCLEAR ASS'N (July 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/switzerland/.

246. *Anti-nuclear protests attract 20,000*, SWISSINFO (May 22, 2011), https://www.swissinfo.ch/eng/anti-nuclear-protests-attract-20-000/30291990.

247. James Kanter, *Switzerland Decides on Nuclear Phase-Out*, N.Y. TIMES (May 25, 2011), https://www.nytimes.com/2011/05/26/business/global/26nuclear.html?_r=1.

248. *Switzerland votes to phase out nuclear power*, BBC NEWS (May 21, 2017), https://www.bbc.com/news/world-europe-39994599.

249. Reuters Staff, *Switzerland switches off nuclear plant as it begins exit from atomic power*, REUTERS (Dec. 20, 2019), https://www.reuters.com/article/us-swiss-nuclearpower/switzerland-switches-off-nuclear-plant-as-it-begins-exit-from-atomic-power-idUSKBN1YO19J.

facilities and wanted the reactors to be phased out by 2010.[250] This decision was "reversed" in 2009 by allowing for the current operating reactors to be replaced by new reactors as a means to maintain its reliance on nuclear power.[251]

Sweden is currently operating six nuclear reactors which account for around forty percent of its electrical grid sourcing.[252] Despite the smaller number of reactors, they are still in the top ten of both sheer energy production and total percent provided by nuclear power.[253] Its remaining electrical grid is remarkably similar to Switzerland's, discussed above, with a high reliance on hydroelectricity and wind-based sources.[254] Regarding reactions to any of the Big 3 accidents, Sweden had one of the swiftest and most decisive actions in phasing out nuclear power.

In the 1970s Sweden was the largest per capita importer of oil in the world—almost wholly reliant on imports to satisfy its national electrical needs.[255] In response to the 1974 oil shock, Sweden accelerated its nuclear program to the sixth largest per capita capacity in the world and lowered its oil used to a third of the previous amount.[256] This massive growth came to a screeching halt immediately after the Three Mile Island accident in 1979. After the accident, the Swedish Riskdag (Legislative Body) proposed a national referendum on nuclear power phase out which passed.[257] There were serious complaints about the referendum since only three options were presented to the voters and all of them were a differing version of opt-out with no option for maintenance or increase available.[258] The referendum would not allow any further nuclear reactors to be built and set a goal of all reactors to be phased out by 2010.[259]

---

250. *Sweden Reverses Nuclear Phase-Out Policy*, NUCLEAR THREAT INITIATIVE, https://www.nti.org/analysis/articles/sweden-reverses-nuclear-phase-out/ (last visited on Dec. 31, 2020).

251. *Id.*

252. *Nuclear Power in Sweden*, WORLD NUCLEAR ASS'N (Dec. 2020), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/sweden.aspx.

253. *Id.*

254. *Id.* (Hydroelectricity accounting for 38% and wind accounting for 10%.).

255. *Sweden Reverses Nuclear Phase-Out Policy*, NUCLEAR THREAT INITIATIVE, https://www.nti.org/analysis/articles/sweden-reverses-nuclear-phase-out/ (last visited on Dec. 31, 2020).

256. *Id.*

257. *Id.*

258. *Id.*

259. *Id.*

Following the Chernobyl accident there were concerns about the safety of Swedish reactors and overtime there was a handful of reactors decommissioned for safety concerns.[260] Leading up to 2010, the goal of full phase-out was likely achievable but the government entered into an about-face of its nuclear policy and replaced its ten existing reactors with new models.[261] Over the past decade there have been additional shutdowns, but there are plans for replacements and upgrades to current reactors.[262] Besides the economic and environmental impacts of maintaining a strong nuclear program, a major factor in the change of course was the change in public opinion regarding nuclear power.

Prior to the 2009 reversal there was a strong anti-nuclear movement among the populace.[263] This shifted over time to a strong pro-nuclear sentiment, with around sixty-two percent of the populace supporting a nuclear program in the early 2010s.[264] This trend even continued after the Fukushima Daiichi accident, with support remaining the same or continuing to grow to seventy-eight percent in 2018.[265] The current support of the program is a crucial factor in maintaining the current nuclear program and hopefully expanding it. The only risk that Sweden currently could run into is not renovating old reactors or constructing new ones at a sufficient pace to match its needed decommissioning of some reactors. Sweden is currently in a flux of its nuclear future, but it is much brighter than just a decade ago.

VII. Going Forward

The debate on nuclear power and the costs and benefits associated with it have gone on as long as the technology has been available and will continue as long as it used. The major advantages that nuclear provides are its

260. *Sweden Reverses Nuclear Phase-Out Policy*, NUCLEAR THREAT INITIATIVE, https://www.nti.org/analysis/articles/sweden-reverses-nuclear-phase-out/ (last visited on Dec. 31, 2020).

261. *Sweden to Replace existing nuclear plans with new ones*, BBC NEWS (Jun. 18, 2010), https://www.bbc.com/news/10347187.

262. *Country Nuclear Power Profiles – Sweden*, IAEA (2020), https://cnpp.iaea.org/countryprofiles/Sweden/Sweden.htm.

263. *Sweden Reverses Nuclear Phase-Out Policy*, NUCLEAR THREAT INITIATIVE, https://www.nti.org/analysis/articles/sweden-reverses-nuclear-phase-out/ (last visited Dec. 31, 2020).

264. *Id.*

265. *Swedish support for nuclear continues to grow, poll shows*, WNN (Nov. 26, 2019), https://world-nuclear-news.org/Articles/Swedish-support-for-nuclear-continues-to-grow,-pol.

carbon-neutral clean energy status, the highest efficiency and capacity factors, and the long-term sustainability. Some of the main drawbacks of nuclear are the high startup costs, high regulation costs, along with closing the fuel cycle, and the rare risk of accidents. Regardless, climate change is an issue that is coming at the globe faster and faster each year. The continued non-use of nuclear energy is a severe mistake by many individual nations, especially those with heavy industrial capacities.

Nuclear energy is the most effective clean energy choice available as a zero-emission energy source.[266] It allowed the U.S. alone to avoid half a billion metric tons of carbon emissions in 2019, all while maintaining a small land footprint in comparison to solar and wind.[267] This is in comparison to the release of carbon emissions by traditional fossil fuels such as coal, gas, and other burnable sources.[268] It is indisputable that nuclear power is cleaner than traditional fuel sources. Though the use of fossil fuels has many applications outside of the energy industry, in this direct comparison it is the incorrect choice for states to continue to rely on. Ironically enough nuclear power releases less radiation into the environment than any other major energy source, with coal being the largest offender.[269] It is assumed nuclear power alone has prevented upwards of seven million deaths by cutting out CO^2 pollution around the globe.[270]

Nuclear power's small land footprint combined with the highest capacity factor make it the most effective energy source, bar none. In 2019 alone, nuclear power was producing at maximum power ninety-three percent of the time, with the next highest being natural gas at fifty-seven.[271] Nuclear plants require significantly less maintenance than fossil-fuel operators and require re-fueling every two years compared to others which require more continuous upkeep and refueling cycles.[272] Additionally, the operating costs

266. *3 Reasons Why Nuclear is Clean and Sustainable*, ENERGY.GOV (Apr. 30, 2020), https://www.energy.gov/ne/articles/3-reasons-why-nuclear-clean-and-sustainable.

267. *Id.*

268. Pushker Kharecha, *Coal and Gas are far more harmful than nuclear power*, NASA CLIMATE (Apr. 22, 2013), https://climate.nasa.gov/news/903/coal-and-gas-are-far-more-harmful-than-nuclear-power/.

269. Richard Rhodes, *Why Nuclear Power Must be Part of the Energy Solution*, YALE ENV'T (Jul. 19, 2018), https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate.

270. Kharecha, *supra.*

271. *Nuclear Power is the Most Reliable Energy Source and It's Not Even Close*, ENERGY.GOV (Apr. 22, 2020), https://www.energy.gov/ne/articles/nuclear-power-most-reliable-energy-source-and-its-not-even-close.

272. *Id.*

of nuclear plants (in mills per KW-hour) are cheaper than fossil-fuel stations though not as cheap as other renewables.[273]

The majority of purported risks of nuclear power are often misnomers or myths regarding the systems themselves. One of the main fears is the risk of catastrophic accidents involving reactor meltdowns, though only three have occurred since the 1950s. The impacts of all of these accidents combined have done less damage than even a minute selection of some of the accidents involving fossil-fuel accidents.[274] These accidents are exceedingly rare and are often attributed to sheer bad luck or most recently a historically large tsunami. The industry and processes are only becoming more efficient and safer as time goes on with older, risker reactors going permanently offline or being replaced. Additionally, the standards regarding reporting, regulation, and control of reactors and the material itself are becoming more and more stringent as time goes on.

Another falsely purported issue is the fuel cycle of Uranium and other isotopes within the nuclear power system. The reserves of nuclear fuel are nearly infinite with Uranium alone being one of the most abundant resources on Earth.[275] Admittedly, the issue of nuclear waste storage was once a major issue within the international community but in the last decades this has been mostly solved. First, states can recycle the waste itself and reuse it in the system again, extending the life cycle of it while preventing waste from being created.[276] Second, the long-term storage of nuclear waste was an issue due to inefficient storage standards and technology. This has become an almost non-issue with operating states either creating their own storage deposits or exporting the waste to other nearby countries.[277] There is the issue bad faith state actors are able to acquire Uranium, specifically enriched, but this issue is handled via non-proliferation treaties. The breadth of that topic alone warrants its own article, especially with recent developments in the Iran-US nuclear agreements.

Regarding the U.S. specifically, the need for an increase in nuclear power is ever apparent. While the U.S. is enjoying a boom in shale oil and

273. Debashree Sen, *Nuclear Energy Vs. Fossil Fuel*, SCIENCING (Sep. 2, 2019), https://sciencing.com/about-6134607-nuclear-energy-vs--fossil-fuel.html.

274. Richard Rhodes, *Why Nuclear Power Must be Part of the Energy Solution*, YALE ENV'T (Jul. 19, 2018), https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate.

275. Sen, *Supra.*

276. Rhodes, *Supra.*

277. *Id.*

gas production the fuel cycle will eventually run out regarding fossil-fuels. Purportedly the world's liquid fuel supply will reach its demand limit around 2050 and coal lasting a longer period.[278] Even with this being a relatively long off period, it will arrive sooner than expected. The transition to sustainable alternatives must begin soon or the steep drop-off cliff will be catastrophic for U.S. energy prices and independence. Additionally, as the U.S. expands their influence through increased exportation of technology and reactors, they will be able to compete with other states in the market, specifically China and Russia.

VIII. Conclusion

The history of nuclear power has shown an industry that, while having some pitfalls, is a source of reliable, clean, and sustainable energy. The challenge of climate change is upon the globe and is something that countries cannot reckon with without a massive re-scaling and rebuilding of our energy systems. The accidents at Three Mile Island, Chernobyl, and Fukushima Daiichi were tragic but also moments to learn from when building the industry going forward. The protection of the human race and our only home will require nations around the globe to commit to clean, sustainable, and reliable energy. The answer has been in front of them for over half a century and it will always be nuclear power.

278. *Does the world have enough oil to meet our future needs?*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/tools/faqs/faq.php?id=38&t=6. (Jan. 30, 2021).