The International Atomic Energy Agency's Plan

Regarding Safety of Nuclear Meltdown Sites Between 2025 And 2040

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Introduction

The use of nuclear energy is a relatively cleaner, more sustainable alternative for energy production in terms of carbon emission. However, nuclear energy still has risks associated with it making it less widely adopted. These issues should inform the United Nations's Committee on Sustainable Energy and safety around the historic nuclear meltdown sites. We, the International Atomic Energy Agency, have developed the following proposal to better safeguard the public of the radioactive effects of nuclear energy by developing a comprehensive plan to inform the public of the danger of nuclear energy and radioactive materials in general, developing new storage methods for nuclear waste, and developing new regulation on the development and use of nuclear energy.

General Overview of Nuclear Energy Generation

Nuclear power is one of the principal ways countries produce energy sustainably. Despite being among the ranks of coal and wind energy in terms of energy cultivation, nuclear power is quite unique in its relative sustainability. This sustainability is allowed for by nuclear energy, low carbon and heavy metal production due to processes such as Vitrification.[1] [2] All current nuclear power plants work by taking the heat from the decay of radioactive materials, such as uranium, to generate electricity mainly through the use of steam turbines.[3] This process is known as fission; and it occurs as radioactive materials, which are composed of highly unstable atoms, decay. When neutrons hit the unstable radioactive materials, they split into lighter elements until they become smaller, more stable elements that either don't absorb neutrons as often or don't split apart as often when hit with neutrons.[4] Another process that is currently under development is fusion, which uses smaller atoms such as isotopes of hydrogen, and then converts them to larger molecules to produce heat. The waste produced by fusion is far less dangerous than fission with current fusion proposals producing inert helium while the waste of fission processes produce large amounts of radiation and are highly toxic.

Threat Mitigation For Current Nuclear Energy

The toxic and radioactive nucleotide wastes produced by the fission reactions as well as the heat emitted from the nuclear reactions are what make them dangerous. These hazards can be

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[1] Weber, Joscha. "Fact check: Is nuclear energy good for the climate?" dw.com, November 29, 2021, https://www.dw.com/en/fact-check-is-nuclear-energy-good-for-the-climate/a-59853315.
[2] rook, Barry W., Agustin Alonso, Daniel A.Meneley, Jozef Misak, Tom Bleese, Jan B.van Erpf, "Why Nuclear Energy Is Sustainable and Has to Be Part of the Energy Mix," Sustainable Materials and Technologies 1-2 (December 2014): 8–16, https://doi.org/10.1016/j.susmat.2014.11.001.
[3] "Nuclear Power Plant," Nuclear Power for Everybody, accessed May 24, 2022, https://www.nuclear-power.com/nuclear-power-plant/.
[4] "Radioactive Decay" Nuclear Power for Everybody, accessed May 24, 2022, https://www.nuclear-power.com/nuclear-power/reactor-physics/atomic-nuclear-physics/radioactive-decay/.

mitigated through the use of multi-layered shielding and a reliable and effective cooling system.[5] If the reactor core gets too hot, it will proceed to melt down, releasing the dangerous radioactive materials from within.[6] There are two types of systems that keep nuclear reactors from failing catastrophically: active systems and passive systems. Passive systems rely on the design of the reactor to prevent the reactor from overheating while active systems utilize pumps, sensors, fans, and other pieces of equipment to keep the reactor safe and operational.[7]

Control

The primary way to rapidly contain a fission reaction within a reactor is the use of control rods. These rods contain materials called neutron poisons that absorb neutrons readily but don't undergo fission. These control rods contain boron carbide and other neutron poisons which allow these rods to control or even stop a nuclear reaction rapidly by being pulled in and out of a nuclear reactor.[8] These control rods are the safeguards that are used to stop a nuclear reaction in an emergency.[9] Neutron poisons can also be formed by nuclear reaction or introduced in another such as the fuel rods. Generally neutron poisons that are not formed by the nuclear reaction but also not in the control rods are meant for long term control of the nuclear reaction as the level of these poisons take more time to change.[10] Those neutron poisons formed by the nuclear reaction

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[5] "Multiple Barriers to Radionuclide Release" Nuclear Power for Everybody, accessed May 24, 2022, https://www.nuclear-power.com/nuclear-power/reactor-physics/nuclear-safety/multiple-barriers-to-radionuclide-release/.
[6] "Nuclear Fuel Melting - Melting Point of UO2," Nuclear Power for Everybody, accessed May 24, 2022, https://www.nuclear-power.com/nuclear-power-plant/reactor-and-power-plant-materials/nuclear-fuel-melting/.
[7] "Safety Systems" Nuclear Power for Everybody, accessed May 24, 2022, https://www.nuclear-power.com/nuclear-power/reactor-physics/nuclear-safety/safety-systems/.
[8] United States Nuclear Regulatory Commission, "NRC: Glossary -- Nuclear Poison (or Neutron Poison)," www.nrc.gov, March 9, 2021, https://www.nrc.gov/reading-rm/basic-ref/glossary/nuclear-poison-or-neutron-poison.html.
[9] "Control Rods," Nuclear Power for Everybody, n.d., https://www.nuclear-power.com/nuclear-power-plant/control-rods/.
[10] "Boric Acid – Chemical Shim," Nuclear Power for Everybody, n.d., https://www.nuclear-power.com/glossary/boron-10/boric-acid-chemical-shim/.

can unintentionally stall out a nuclear reactor, which is extremely problematic, as can be seen during the Chernobyl disaster. [11]

[11] Manley, Scott. "Why Chernobyl Exploded - the Real Physics behind the Reactor," YouTube, June 8, 2019, https://www.youtube.com/watch?v=q3d3rzFTrLg. (Accessed June 6, 2022)

The Benefits of Nuclear Energy

Despite the similarities to coal and wind energy in terms of energy cultivation, countries around the world have multiple unique incentives to use nuclear power plants. One of the most obvious benefits of nuclear power plants is that they provide many jobs, even when compared to other energy sources. For example, the average gas plant employs about 60 people, whereas the average nuclear power plant employs approximately 600 people.[12] Although the higher employment could translate to lower efficiency to run the plant, the increased employment provided by nuclear power plants leads to greater economic growth. This is coupled with the fact that nuclear power plants are often situated in or around rural areas, which allows these areas to undergo both a population boost and economic growth.[13] Considering the fact that rural areas have much lower job growth than urban areas, especially in the United States, investing in nuclear power plants can help to reinvigorate these areas.[14] Another benefit of nuclear power plants is that they are commonly known to employ many veterans.[15] Although increased employment of any demographic is generally beneficial, it has more of a positive impact on veterans because they generally have higher unemployment rates.[16] By employing many veterans, nuclear power plants help to boost the economic status of this demographic.

A number of these economic benefits of nuclear power are shared by other energy sources. However, compared to other power generation technologies, nuclear power causes the

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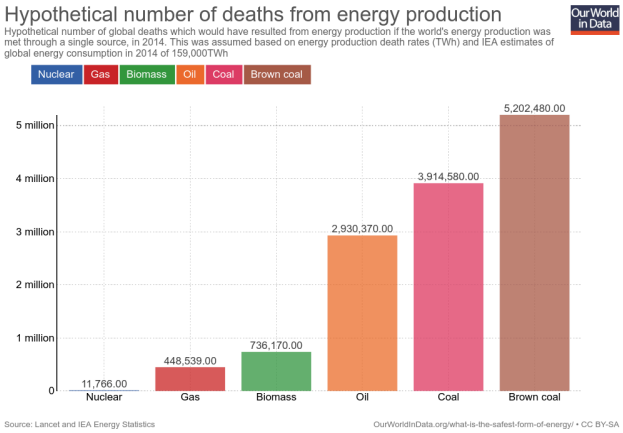
[12] James O. Ellis and George P. Shultz, "Chain Reactions: Before we jettison nuclear energy, let's count the costs: to the economy, to the environment, and to national security," Hoover Digest, 2018, https://link.gale.com/apps/doc/A526575474/OVIC?u=nysl_me_71_svhs&sid=bookmark-OVIC&xid=bc898f3c.
[13] Hoover Digest, "Chain Reactions: Before we jettison nuclear energy, let's count the costs: to the economy, to the environment, and to national security"
[14] David Swenson, "Much of rural America is doomed to decline," High Country News, July 9, 2019, https://www.hcn.org/articles/growth-sustainability-much-of-rural-america-is-doomed-to-decline.
[15] Hoover Digest, "Chain Reactions: Before we jettison nuclear energy, let's count the costs: to the economy, to the environment, and to national security"
[16] Employment Situation of Veterans News Release," Bureau of Labor Statistics, April 21, 2022, https://www.bls.gov/news.release/vet.htm.

least human injury when regulated correctly.[17] Furthermore, although nuclear power is infamous for its supposedly uniquely dangerous radiation, nuclear power plants actually release much less radiation into the environment than coal power.[18] Not only are the radiation effects of nuclear energy overstated, but nuclear energy is also a much healthier option compared to other energy sources.



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Other than in the areas of economy and health, nuclear power has important environmental advantages. For example, unlike some other energy sources, nuclear power doesn't produce carbon dioxide.[20] Carbon dioxide is harmful to the environment and contributes to climate change. Additionally, nuclear power doesn't pollute the water or the air as much compared to pre-existing alternatives, which is of utmost importance for the survival of wildlife.[21] Nuclear power plants are actually the dominant producers of nearly pollution-free and carbon-dioxide-free energy, producing almost two-thirds of this energy.[22] Because of this environmental benefit, nuclear power plants can be built to transition from energy sources that traditionally produce many greenhouse gasses.

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[17] Hoover Digest, "Chain Reactions: Before we jettison nuclear energy, let's count the costs: to the economy, to the environment, and to national security"
[18] Ibid, 2
[19] Richie, Hannah. "What are the safest and cleanest sources of energy?", Our World in Data, February 10, 2020, https://ourworldindata.org/safest-sources-of-energy.
[20] Ibid, 1
[21] Ibid, 2
[22] Ibid, 1

Another important beneficial characteristic of nuclear power is that the operators of nuclear power plants self-regulate effectively.[23] This means that privately-owned nuclear power plants can regulate themselves competently, with minimal government oversight, in order to avoid accidents. This is especially true after the incidents of Chernobyl and Three Mile Island, because a mistake by one nuclear power plant would reflect negatively on the entire nuclear industry. These incidents also led to the growing trend towards more government regulation of nuclear energy, which is important so that nuclear power plants remain as safe as possible.

As nuclear fission was discovered only in 1938, nuclear energy is a relatively new technology, and is still being improved upon to this day.[24] This allows for exciting new nuclear endeavors to be possible, such as the research of nuclear fusion. The potential of fusion is brobdingnagian: it "could generate four times more energy per kilogram of fuel than fission (used in nuclear power plants) and nearly four million times more energy than burning oil or coal." [25] The powerful future potential of nuclear energy ensures that it will only grow in relevance in the future.

[23] Ibid, 3
[24] "History of Nuclear Energy," World Nuclear Association, 2020, History of Nuclear Energy - World Nuclear Association (world-nuclear.org).
[25] Barbarino, Matteo. "What is nuclear fusion," International Atomic Energy Agency, March 31, 2022, https://www.iaea.org/newscenter/news/what-is-nuclear-fusion.

The Drawbacks of Nuclear Energy

One of the most obvious problems with nuclear power is the fact that its use releases radioactive waste.[26] This radioactive waste can come in the form of spent nuclear fuel rods, which are fuel rods that have been removed from the reactor core because most of the fuel was used up.[27] Even though most of the fuel in these spent fuel rods has been used up, the rods are still highly radioactive and produce tremendous amounts of heat.[28] This means that the spent rods are too dangerous to simply dispose of in the open like garbage. This highlights another problem: nuclear waste is very difficult to dispose of. Oftentimes, attempts to dispose of nuclear waste interferes with and harms local wildlife. For example, Japan announced their plan to dump nuclear wastewater from the Fukushima nuclear power plant into the Pacific Ocean. This has elicited concerns from Japanese fishing communities, who believe that the wastewater, which contains the radioactive material tritium, would harm marine life in the Pacific Ocean.[29] Generally, the spent fuel rods are almost always stored several feet under water in dedicated, isolated cooling pools, which are generally located at the nuclear power plants themselves until a permanent storage method is used, such as borehole repositories or deep repositories.[30] Here is a picture of spent nuclear fuel rods stored underwater.

[31]

[26] "Backgrounder on Radioactive Waste," United States Nuclear Regulatory Commission, July 23, 2019, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html.
[27] United States Nuclear Regulatory Commission, "Backgrounder on Radioactive Waste"
[28] United States Nuclear Regulatory Commision, "Backgrounder on Radioactive Waste"
[29] McCurry, Justin. "Fukushima: Japan announces it will dump contaminated water into sea," The Guardian, April 13, 2021, Fukushima: Japan announces it will dump contaminated water into sea | Fukushima | The Guardian.
[30] "Safer Storage of Spent Nuclear Fuel," Union of Concerned Scientists, March 24, 2011, https://www.ucsusa.org/resources/safer-storage-spent-nuclear-fuel.
[31] United Nations, "Iran Needs More Time to Consider Nuclear Fuel Agreement, Says UN Atomic Watchdog," UN News, October 23, 2009, https://news.un.org/en/story/2009/10/318832-iran-needs-more-time-consider-nuclear-fuel-agreement-says-un-atomic-watchdog.https://news.un.org/en/story/2009/10/318832-iran-needs-more-time-consider-nuclear-fuel-agreement-says-un-atomic-watchdog.

While other forms of energy produce waste, the uniquely dangerous characteristics of nuclear waste can make nuclear energy seem unappealing. Exposure to radioactive waste can cause Acute Radiation Syndrome, a type of radiation poisoning, which causes nausea, vomiting, diarrhea, internal bleeding, loss of consciousness, and even death, while at the same time increasing the risk of cancer.[32] Considering these effects of exposure to nuclear waste, it is no surprise why certain groups are concerned about the implementation of nuclear energy. Another issue surrounding nuclear energy revolves around certain storage units that hold nuclear waste. Some of these storage units are threatened, such as the Runit Island depository. This repository seems to be forming slight cracks on the dome covering the nuclear waste; additionally, water levels around the island are rising, leading to the possibility that the dome will be sunk underwater and have a total breach.[33]

The numerous advantages and disadvantages of the use of nuclear energy help to illustrate the complexity in attempting to classify it in a positive or negative light. However, these complexities are important so that one may better understand the situations in which nuclear energy is practical. Additionally, understanding the pros and cons of nuclear power will help to drive what its future will look like, from the standpoint of improving upon the advantages and mitigating the disadvantages of nuclear power.

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[32] CDC, "CDC Radiation Emergencies | Acute Radiation Syndrome: A Fact Sheet for Physicians," www.cdc.gov, April 22, 2019, https://www.cdc.gov/nceh/radiation/emergencies/arsphysicianfactsheet.htm#:~:text=Acute%20Radiation%20Syndrome%20(ARS)%20

[33] Rust, Susanne. "How the U.S. Betrayed the Marshall Islands, Kindling the next Nuclear Disaster." Los Angeles Times. Los Angeles Times, November 10, 2019. https://www.latimes.com/projects/marshall-islands-nuclear-testing-sea-level-rise/.

Contextualization: The Cold War

Tsutomu Yamaguchi couldn't believe the events that occurred 2 days ago, he immediately reported to his office in Mitsubishi's Nagasaki office and described the events that occurred in Hiroshima, a single B-29 dropped a single bomb and wiped Hiroshima off the map. His superiors deemed him to be mad, a city gone with one bomb? Impossible, there is no way the Americans were able to produce such a bomb. Soon enough, over Nagasaki would fly a single B-29, part of the 393rd bomb group USAAF, nicknamed Bockscar by its crew, and in a matter of minutes Nagasaki would be wiped off the map as well. Tsutomu Yamaguchi would survive once again as he did in Hiroshima; however, Japan would not.[34]

[35]

Following the second nuke, members of the Imperial Japanese high command decided to give in and signed the unconditional surrender given during the Potsdam Conference. World War II was officially over as an Allied victory standing on the millions of lives given up in the 6 brutal long years. Many were glad it was over, however a concern that was brewing among men during the war began to resurface and that was whether the Soviet Union could be trusted or not. Many American and British soldiers began to feel resentment as it was the Soviets who marched into Berlin rather than them and wondered if it was the right move; and even General Patton

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[34] Hdogar. "The Man Who Survived Both Atomic Bombings." Medium. History of Yesterday, February 25, 2022. https://historyofyesterday.com/the-man-who-survived-both-atomic-bombings-a5e56d113757.

[35] National Museum of the United States Air Force, "Boeing B-29 Superfortress," National Museum of the United States Air ForceTM, n.d., https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196252/boeing-b-29-superfortress/.

began to believe that they had “defeated the wrong enemy” as the Soviets began washing over Eastern Europe. This distrust went as far as to the point where generals were drawing up Operation Unthinkable[36] which was an operation to fight the Soviets right after World War II. The Soviets seemed to ignore requests from the rest of the Allies, such as allowing free democratic elections, and began to rule eastern Europe with an iron fist.

With tensions growing between the US and the Soviet Union, the US felt relatively safe due to their new weapon, the atomic bomb, since it seemed like it would take the Soviets decades to reproduce such a bomb. However the Soviets managed to recreate the bomb by 1949, 4 years after the nuking of Hiroshima and Nagasaki. This was mainly due to the spies sent out to infiltrate American facilities and figure out the details of the “Manhattan Project”. Even though the Soviet espionage program faced the FBI, which managed to stop a great amount of infiltration, some managed to slip through the cracks and in 1943, 2 scientists were working alongside the rest of the American scientists as Soviet spies.[37] The Soviets were quick to learn that the Manhattan Project was the development of the atomic bomb and with 2 scientists working on it in the US, the Soviets were able to start the development of their own atomic bomb back in the Soviet Union and complete it much earlier than expected. What followed was a military standoff between the two superpowers, a string of

[36] The National Archives. “'Operation Unthinkable'.” The National Archives, , May 14, 2019. https://www.nationalarchives.gov.uk/education/resources/cold-war-on-file/operation-unthinkable/

[37] Manhattan project: Espionage and the Manhattan Project, 1940-1945. Accessed May 24, 2022. https://www.osti.gov/opennet/manhattan-project-history/Events/1942-1945/espionage.htm#:~:text=At%20least%20two%20other%20scientists,not%20assigned%2

proxy wars and events that brought the world closer again to being plunged into another world war. This period will be known as the Cold War.

During the Cold War two major players, namely the United States and the Soviet Union, were both armed with nuclear arsenals capable of blowing each other off the face of the Earth. However, they were both scared of the nuclear responses if one were to initiate. Due to the power of nukes, the two nations decided to take part in proxy wars where they would support sides during a war. As tensions grew alliances formed, the major ones being NATO and the Warsaw Pact, and at each were the leading nations the United States and the USSR respectively. Nations part of either alliance began developing their own nukes for protection. The two superpowers would continue to duke it out through technology and achievements as they competed in the olympics, raced to the moon, produced weaponry, and facilitated proxy wars. Eventually the Cold War would come to an end as the Soviet Union was dismantled from the inside out. True communists no longer believed in Mikhail Gorbachev and deemed him unfit to lead the nation, however it was already too late as the satellite states of the USSR gained their independence one by one. On January 20th, 1953, as President Eisenhower would be inaugurated as the US president and he would challenge this notion with the "Atoms for Peace". The idea would be changing the weapons into a form of energy and drive away the idea that nukes were weapons. During this program, scientists worked hard to convert the nuclear weapons into a massive power plant to produce energy. It was finally achieved when they finalized the construction of the Shippingport Nuclear Power Station[38]. Opened on May 26, 1958, it was the very first commercial nuclear power plant to exist and was capable of being flexible to different types of cores. This initiative started another race between the Soviets and the Americans to hurry up and

[38] "Shippingport Nuclearpower Station." ASME. Accessed May 25, 2022. https://www.asme.org/about-asme/engineering-history/landmarks/47-shippingport-nuclear-power-station

establish nuclear power plants for peacetime uses. After the start of the competition, the US made policies granting any nation information about the development of nuclear reactors giving nations the required scientific knowledge to make their own power plants[39]. However, it is considered to be a double edged sword since the declassification of nuclear power plants enabled nations to develop their own nuclear weapons which defeated the purpose of the whole "Atoms for Peace" program of lowering the usage of nuclear technology as weapons. The result was the creation of multiple power plants in the US and the Soviet Union along with the spread of nuclear power plants among other nations such as France, Britain and Germany.

Public Opinions

Now not only did the Cold War give birth to nuclear energy, it also brought in a wave of public opinions which were split between being positive and negative. With horrific incidents occurring at power plants such as Chernobyl, Mayak Kyshtym, Sellafield reactor, and SL-1 prototype in Idaho, public opinions quickly turned sour. For example, during the 3 Mile Island incident, the Nuclear Regulatory Commission (NRC), was not clear about their information and stated lies to keep the people calm even though the situation was much worse than said.[40] A lot of these incidents occurred due to their speedy construction and human error; however, this was unavoidable as nations were racing to create more nuclear power plants. The Cold War also struck fear in residents near nuclear power plants since they knew the destructive capability of a nuke. It didn't help that a movie describing a total nuclear meltdown, The China Syndrome, was released 12 days prior to the Three Mile Island event and struck fear into residents of

[39] "Atoms for Peace Program ." Encyclopedia of Science, Technology, and Ethics. . Encyclopedia.com. (May 23, 2022). https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/atoms-peace-program
[40] Blakemore, Erin. "How the Three Mile Island Accident Was Made Even Worse by a Chaotic Response." History.com. A&E Television Networks, March 27, 2019. https://www.history.com/news/three-mile-island-evacuation-orders-controversy.

Middletown, Pennsylvania. The movie and the 3 Mile Island would bring major change to the nuclear industry, out of the incident would rise the biggest anti-nuclear movement. The NRC were preaching for years that a nuclear meltdown is impossible and safety was key which kept the anti-nuclear movement at bay however the lying from the NRC and the 3 Mile Island Incident gave the movement credit and the movement grew in size. Massive protests took place, the most notable one being a protest in New York City in 1979 including over 200,000 participants all rallied to fight off the nuclear industry.[41] The public opinion of the industry continued to deteriorate as the years went on and incidents occurred, and we can see a rapid increase of support for the anti-nuclear movement after the Chernobyl incident. Most European nations saw a jump of 40% in opposition to nuclear power within their populations. [42]

[41] History.com Editors. "Three Mile Island." History.com. A&E Television Networks, December 18, 2009. https://www.history.com/topics/1970s/three-mile-island#section_5.
[42] Yontrarak, Pat. "The Chernobyl Disaster: Public Responses." The Chernobyl disaster: Public responses. Accessed June 6, 2022. http://large.stanford.edu/courses/2018/ph241/yontrarak1/.

The Chernobyl Disaster

Despite the numerous benefits of nuclear energy, one instance of the potential damages of nuclear energy is the devastating Chernobyl explosion in Ukraine of 1986, known as one of the worst nuclear disasters in history.[43]

Context

During the Arms Race, the U.S. and the Soviet Union began specializing in applications of nuclear energy outside of weaponry. With the Americans developing the first commercial nuclear power plant in 1958, the Soviets followed along and began prioritizing nuclear power generation.[44] Thus, during the Cold War, Soviet engineers created many kinds of nuclear reactors based on compactness and efficiency. They also developed reactors requiring more expensive design features to compete with Western markets. The Soviet Union's development of nuclear arms and its nuclear energy prowess became prominently known globally and made them fearsome to other nuclear powers such as the United States. Soviet history professor, Paul R. Josephson states that "the public enthusiastically embraced atomic energy as a symbol of Soviet scientific prowess and cultural achievement"[45]. However, despite the recognition of its great nuclear power, on April 26, 1986, the incident involving a nuclear reactor in Chernobyl, Ukraine greatly shifted the Soviet Union's nuclear growth as well as the reputation of the usage of nuclear energy as a whole.

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[43] "Chernobyl disaster." In *Encyclopedia Britannica*, April 19, 2022. https://www.britannica.com/event/Chernobyl-disaster

[44] "Shippingport Nuclearpower Station", ASME.

[45] Josephson, Paul R. "Atomic Energy." In *Encyclopedia of Russian History*, edited by James R. Millar, 93-96. Vol. 1. New York, NY: Macmillan Reference USA, 2004. *Gale In Context: World History* (accessed May 18, 2022). https://link.gale.com/apps/doc/CX3404100094/WHIC?u=nypl&sid=bookmark-WHIC&xid=302397f9

The Incident

The Chernobyl disaster occurred due to flaws in reactor design in combination with human error in a poorly designed experiment. The Chernobyl Power Complex, in Chernobyl, Ukraine, consisted of four nuclear reactors (Chernobyl 1, Chernobyl 2, Chernobyl 3, and Chernobyl 4) capable of generating 1,000 megawatts of electric power. The complex was located in Pripyat, which was 10 mile northwest from the city of Chernobyl.

On April 25, the day before the disaster, operators working at Chernobyl 4 reactor ran a system test to see if Chernobyl's nuclear reactors can be safely shut down and moved on to generator power.[46] The test was to see if the reactor can produce energy based on the remaining momentum of the turbines after it is shut down. The next day, operators shut down the reactor's power-regulating system and emergency safety systems , removed almost all of the control rods stabilizing the core, and ran the reactor at a continual 7 percent power.[47] These poorly designed experiments led to a sudden power surge causing two explosions. The first explosion occurred within the reactor. However, seconds later, the second explosion launched nuclear fuel material and structural scrap and exposed the radioactive reactor core to the atmosphere. The initial explosions and injuries by the explosion killed two workers but around 30 operators and firemen died due to the radiation within three months.[48]

The explosion on April 26, 1986 left a large amount of radioactive substances drifting through the air for the next ten days. Although larger radioactive materials remained as dust and debris and fell near Chernobyl 4, lighter radioactive materials were carried to Belarus, Russia,

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[46] "Chernobyl Explosion." In Gale World History Online Collection. Detroit, MI: Gale, 2022. Gale In Context: World History (accessed May 18, 2022). https://link.gale.com/apps/doc/IEVDXZ902770059/WHIC?u=nypl&sid=bookmark-WHIC&xid=967b62e2.

[47] *Encyclopedia Britannica,* "Chernobyl disaster."

[48] "Chernobyl Accident 1986." Chernobyl Accident | Chernobyl Disaster - World Nuclear Association. World Nuclear Association. Accessed May 18, 2022. https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx

Ukraine and other parts of Europe.[49] This radioactive activity triggered large-scale evacuations and the creation of the Chernobyl Exclusion Zone for public safety from radioactivity in the Soviet Union.

The Local Effects of the Chernobyl Disaster

Shortly after the explosion, to extinguish the fire and limit radioactive materials spread, emergency crews used helicopters to pour tons of boron, clay, lead, and sand atop the reactor debris. Furthermore, the residents of Pripyat nearby were ordered to evacuate the day after the explosion.[50] On April 28, Swedish monitoring stations reported high levels of radioactivity in the air and pressed for an explanation. In response, the Soviet government made public the nuclear accident at Chernobyl and set off international fear of radioactive emissions.[51]

In the weeks following the disaster, the Soviet government cut down a pine forest nearby to reduce radioactive contamination and many personnels on the site of the explosion trying to limit radioactivity leaks from the damaged reactor's core. Eventually, over 600,000 people involved in cleanup were exposed to high doses of radiation.[52] The Soviet Union also developed a circle-shaped exclusion zone around the nuclear plant covering around 1,017 square miles known as the Chernobyl Exclusion Zone. People were forbidden to live within the exclusion zone but scientists, scavengers, and others with permits were allowed to enter the zone for a limited period of time.[53] However, following the end of the Soviet Union and Cold War in 1991, control of the Chernobyl Exclusion Zone was passed onto Ukraine.

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[49] Gale In Context: World History, "Chernobyl Explosion," under "EXPLOSIONS AND FIRE"
[50] Gale In Context: World History, "Chernobyl Explosion," under "EMERGENCY RESPONSE"
[51] *Encyclopedia Britannica,* "Chernobyl disaster."
[52] Gale In Context: World History, "Chernobyl Explosion," under "CLEANUP"
[53] *Encyclopedia Britannica,* "Chernobyl disaster."

Misregulation

In 2011, after the Ukrainian government gained control of the Chernobyl Exclusion Zone, parts of the exclusion zone, including Chernobyl and the abandoned city of Pripyat, were opened to organized tour groups.[54] According to Francesca Street, Chernobyl became a hotspot for "dark tourism", "a term for visiting sites associated with death and suffering, such as Nazi concentration camps".[55] In other words, despite the devastating event that took place decades ago, regulations have gradually been lifted on the radioactive site.

Furthermore, during the Russian invasion of Ukraine in 2022, Russian forces invaded Chernobyl and were likely exposed to high amounts of radiation. During their invasion, Russian troops were reported to be kicking clouds of radioactive dust as a result of driving armored vehicles through Chernobyl's highly radioactive "red forest".[56] This shows how the remnant of the nuclear disaster and misregulation of said remnant still affect people today. Therefore, Chernobyl, Ukraine needs more regulation on their site of nuclear disaster.

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[54] Ibid.
[55] Street, Francesca. "Chernobyl and the Dangerous Ground of 'Dark Tourism'." CNN. Cable News Network, June 25, 2019. https://www.cnn.com/travel/article/dark-tourism-chernobyl/index.html.
[56] McFall, Caitlin. "Russian Troops Dug Trenches in Chernobyl's Highly Radioactive 'Red Forest'." New York Post, April 9, 2022. https://nypost.com/2022/04/09/russian-troops-dug-trenches-in-chernobyls-highly-radioactive-red-forest/.

Proposal

There are many issues with atomic energy including its hazardous nature, economic problems, and negative public perception. Due to the fact that there are many factors weighing down atomic energy in the present, there is not any one definite solution that will solve all the problems with atomic energy. However, there are a few notable possibilities to help minimize the disadvantages associated with atomic energy.

One big issue with nuclear energy is the radioactive waste it produces. The U.S. and other nations produce a lot of nuclear waste from nuclear reactors and nuclear weapons. The biggest issue is the high-level nuclear waste that is produced which remains "radioactive for tens of thousands of years".[57] For instance, in Chernobyl, the lack of regulation on radioactive debris and sentiment created decades ago can be seen having negative consequences even today. Theoretically, an effective and cost efficient way to permanently dispose of this waste is to build deep repositories, which are large storage facilities deep within the Earth's crust, for long term storage without exposure to humans. However, the building of deep repositories in the US and other nations is still expensive and faces political and public opposition caused by environmental concerns. As a result, lots of highly radioactive waste is still kept above ground in nuclear facilities that are still subject to human exposure. However, Deep Isolation is a company that proposes borehole repositories that utilizes directional drilling used in the gas industry to drill deep boreholes and deposit nuclear waste. It deposits nuclear waste in "Deep, stable rock formations hundreds of meters underground".[58] The deep isolation of nuclear waste provides a permanent and safe disposal of high and low level nuclear waste. This method is cheaper to use

[57] Vidal, John. "What Should We Do with Radioactive Nuclear Waste?" The Guardian. Guardian News and Media, August 1, 2019. https://www.theguardian.com/environment/2019/aug/01/what-should-we-do-with-radioactive-nuclear-waste.
[58] "Nuclear Waste Repository." Deep Isolation, May 8, 2022. https://www.deepisolation.com/technology/.

because it utilizes existing technology and is relatively safer for the environment and workers. In addition, the company also has methods to retrieve deposited nuclear waste if necessary.

Additionally, the development of new Generation IV nuclear reactors allows for less nuclear waste to be produced in the first place compared to the generation II and III reactors that are still in operation today, which is critical in allowing for the long-term production and management of nuclear waste using the technique described above. It would also improve safety and efficiency of the nuclear reactor meaning less ore would need to be mined to produce the same amount of power, which is better for the environment.[59] The improved safety associated with improved passive safety features will decrease the probability that major incidents such as Chernobyl and Fukushima occur again in the near future and decrease the rate that nuclear reactor incidents occur over time. These passive safety features will allow the reactor to reach a safe state with less human input leading to less of a chance of human error leading to an incident.[60]

We recommend measures via education of the danger of regions like Chernobyl as a way to decrease the amount of tourism into these regions until reactor 4 and the rest of the Chernobyl power plant can be safely disassembled with a couple number tons of the most radioactive topsoil being buried in large mines and other location to lower human exposure towards it. This education is the best measure to lower the rate of this tourism as making this illegal will only spur more people to attempt to enter the region without the proper safety precautions.[61] It would also mean the tourist who still wants to go to the site will be more informed with the threats and

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[59] "Generation IV Nuclear Reactor - an Overview | ScienceDirect Topics," www.sciencedirect.com, 2018, https://www.sciencedirect.com/topics/engineering/generation-iv-nuclear-reactor.
[60] Generation IV International forum, "Benefits and Challenges," GIF Portal, September 19, 2013, https://www.gen-4.org/gif/jcms/c_40368/benefits-and-challenges#c_43122.
[61] Sue Curry Jansen and Brian Martin, "The Streisand Effect and Censorship Backfire," ResearchGate (University of Southern California, Annenberg School for Communication & Journalism, 2015), https://www.researchgate.net/publication/273947761_The_Streisand_Effect_and_Censorship_Backfire.

dangers of the site. This measure will be mainly targeted towards tourists and be funded with money from carbon taxes as well as other taxes such as congestion taxes. This measure would also have the additional effect of making the public more interested in the technology spurring more research and development into the technology as well as illustrating the fact that nuclear energy can be safe if properly contained.

General Industry Regulation

Another way we can increase the safety of the industry and allow it to expand is through implementation of a carbon tax. Carbon taxes are taxes on fossil fuels that charge companies for the harmful emissions that they produce. It also forces consumers to pay higher costs for things such as electricity and gas. In theory, not only would this benefit the environment by lowering the usage of fossil fuels, but also provide a " powerful monetary disincentive" to switch to renewable energy sources or to develop only renewable energy in areas that don't already have energy infrastructure.[62] This could also be used to fund efforts to better deal with nuclear waste and educate the general public regarding the dangers and advantages of nuclear energy. This incentive to switch to more renewable sources of energy would also benefit the development of atomic energy while maintaining safety associated within the industry. However, this plan has not been tested long-term, so it is hard to determine the effectiveness of this plan. In addition, the short term price increases to gas and electricity may negatively impact consumers leading to disapproval of the plan from the general public. Large companies are also likely to disagree with carbon tax policies, making them harder to implement. Although a carbon tax comes with its short-term losses, we believe that it will positively shift focus on to renewable energy sources

[62] "What's a Carbon Tax?" Carbon Tax Center. Accessed May 24, 2022. https://www.carbontax.org/whats-a-carbon-tax/.

such as nuclear and will benefit the development of nuclear technology. This in turn will improve the safety and effectiveness of nuclear energy long-term.

All of this being said, nuclear energy should still be supplemented by traditional renewable fuels, reliable transmission lines that are well maintained, and systems to prevent nuclear reactors from losing access to their water supply. Traditional renewable energy combined with energy storage provides an effective way to meet peak demand with nuclear energy being most effectively used to meet base load demand.[63] [64] This will limit the use of nuclear power to where they are most effectively used to limit nuclear waste generation. Having many effective long distance transmission lines that are well maintained with the corresponding infrastructure to maintain a larger energy network that is also well maintained is critical to grid stability.[65] [66] Grid Stability is extremely important as it makes sure that the power created by nuclear energy further helps to limit the amount of nuclear waste produced given the energy generated. Without these critical other elements within the power grid being available and effective, many of the safety improvements outlined in this paper will be pointless.

In general the solutions outlined above are pieces that need to be put together to form an effective solution to benefit the development and implementation of nuclear energy to further the goals of the United Nations Committee on Sustainable Energy. A critical part of the future of nuclear energy is support from the general public and political support. Due to lack of support from the public and media after the devastation caused in incidents such as Chernobyl Three Mile Island, nuclear reactors are viewed with skepticism and fear. To solve this, better safety

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[63] Scott Manley, "Why Chernobyl Exploded - the Real Physics behind the Reactor,"
[64] "Energy Storage: The Key to a Reliable, Clean Electricity Supply," Energy.gov, June 23, 2020, https://www.energy.gov/articles/energy-storage-key-reliable-clean-electricity-supply.
[65] Gardy Hillhouse, "What Really Happened during the Texas Power Grid Outage?," www.youtube.com, March 23, 2021, https://www.youtube.com/watch?v=08mwXICY4JM.
[66] Gardy Hillhouse, "What Really Happened during the 2003 Blackout?," www.youtube.com, February 15, 2022, https://www.youtube.com/watch?v=KciAzYfXNwU.

regulations and protocols need to be employed to protect against such disastrous incidents. This includes the development and use of the *Unified System for Information Exchange on Incidents* and *Emergencies and the development of the State-of-the-Art Reactor Consequences Analysis* program by the US government, which allows for better communication between different parties during a nuclear incident to prevent it from getting out of control and turning into a disaster, in addition to helping with the development of new procedures within nuclear energy programs to increase safety.[67] This in turn would positively impact public perception on nuclear energy and the building of nuclear power plants. Public education should also be used to get the general population more familiar with the risks and advantages of nuclear energy, so that the spread of misinformation around nuclear energy can be prevented. Economic plans supported by the government, such as a carbon tax, could also increase the competition of nuclear energy in the energy industry, which also increases safety. Another critical element to aid in the development of nuclear energy is the implementation of new technologies in the nuclear energy industry. Technology such as modular reactors and borehole repositories have the potential to increase the efficiency, safety and cost of nuclear energy. With the advent of new and better technology, public perception on nuclear energy and support for nuclear energy would improve. This proposal also would need up to 100 million dollars through the current funding structure of the United Nation to bring the solutions above to fruition.[68] [69] [70] In addition, the funding could also be used to fund other promising research projects. This proposal will improve the lives of

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[67] World Nuclear Association, "Safety of Nuclear Reactors - World Nuclear Association," world-nuclear.org, March 2021, https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx.

[68] Cullen Howe, "Building a Better (and Cleaner!) Electric Grid,"

[69] Deutsche Welle, "Fact Check: Is Nuclear Energy Good for the Climate? | DW | 29.11.2021," DW.COM, November 29, 2021, https://www.dw.com/en/fact-check-is-nuclear-energy-good-for-the-climate/a-59853315.

[70] United Nations, "How We Are Funded," United Nations Peacekeeping, 2000, https://peacekeeping.un.org/en/how-we-are-funded.

those who live near nuclear reactors, nuclear waste sites, and society as a whole. Furthermore, it will decrease the rate at which people develop Acute Radiation Syndrome and further limit the number of nuclear meltdowns over the next 15 years.

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