International Atomic Energy Agency

MUNUC CHINA ONLINE 2021

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CHAIR LETTER

Dear Delegates,

Welcome to IAEA, our committee for MUNUC China Online 2021. My name is Joseph Pinto and I will serve as your chair. I am from Delaware (though I spent most of my childhood in Massachusetts), and at the University of Chicago I am a second-year triple majoring in Chemistry, Mathematics, and Economics. My MUN experience includes chairing a committee at MUNUC XXXIII, being the crisis director for a committee at ChoMUN XIV, assistant chairing for a crisis committee at MUNUC 32, and preparing to be an assistant chair for the Virgin Group crisis committee at ChoMUN 23. I also chaired a virtual committee at WeMUN this past summer. Additionally, I participated in Model UN in high school, so I know what it's like to be a delegate! Outside of Model UN, I'm a math and physics tutor through the Neighborhood Schools program, helping out at a local high school. I'm also incredibly interested in energy policy, and worked this past summer at a DC-based think tank researching nuclear energy policy.

In this committee we will tackle the pressing issue of sustainable development of atomic energy through the lens of technology. It is a broad topic that has many possible solutions, so I anticipate well-researched ideas in a wide number of areas, and I hope to see some wonderful debate and collaboration during the committee. This is a difficult question that cannot be solved with a simple solution.

Please do not hesitate to reach out with any questions, comments, song suggestions, or concerns at cso@munuc.org. I look forward to seeing all of you in committee!

Best,

Joseph Pinto

HISTORY OF THE COMMITTEE

In an effort to mitigate the dangers brought about by the revolution of atomic technology, the United Nations convened the International Atomic Energy Agency (IAEA). The IAEA was founded in 1957 to deal with the complex and diverse issues that newly developed nuclear technologies posed.[1] The IAEA's mission is strongly aligned with the "Atoms for Peace" proposal set forth by U.S. President Eisenhower.[2] Under this mission, the IAEA has worked diligently to secure the use of nuclear technology for the benefit of mankind and worked to control and prevent the proliferation of nuclear weapons.[3]

The IAEA was founded in an era that was particularly concerned with the proliferation of weapons of mass destruction. Today, the IAEA incorporates a broader focus on the implications that nuclear technology, including nuclear energy. Nuclear energy poses a growing role in producing energy for society and the IAEA has a developing responsibility to mitigate the potential negative ramifications of a world increasingly dependent on nuclear energy. As the uses for nuclear technology expand into fields as diverse as agriculture and medicine, the mission of the IAEA remains constant. The IAEA is ready to ensure that the development and spread of nuclear technology occurs along safe, secure, and peaceful lines. At the same time, the IAEA stands as a committed international organization dedicated to ensuring that the threats that nuclear technology pose to society remain distant and that nations are diligent in their efforts to protect humanity from nuclear catastrophe.

[1] International Atomic Energy Agency, History.
[2] Ibid 1.
[3] Ibid 1.

TOPIC: THE DEVELOPMENT OF NUCLEAR ENERGY

Statement of the Problem

The advent of nuclear energy in the mid-twentieth century was symbolic of a global partnership for scientific advancement, demonstrating the willingness and capacity of nations to harness the potential of a new energy source.[4] Until then, electricity was produced mainly by burning fossil fuels such as coal, oil, and natural gas.[5] In the 1960s, France, the Soviet Union, the United States, and the United Kingdom successfully completed the construction of nuclear power reactors capable of producing electricity. By the 1970s, 15 nations were operating a total of 90 nuclear power plants.[6] Interest in nuclear energy development elevated after the Arab Oil Embargo in 1973, when Organization of the Petroleum Exporting Countries (OPEC) member nations threatened to cut oil production and ban petroleum exports to targeted nations.[7] The resulting economic pressure served as a glaring reminder that many countries—even economic powerhouses such as the United States—were at the mercy of the "oil weapon."[8] As a result, these countries developed increased nuclear technology ambitions to reduce energy dependence.

Today, 31 nations collectively operate more than 430 civil nuclear power reactors, supplying 16% of the world's electricity demand and accumulating a combined number of 14,000 reactor-years of operation experience.[9,10] Nuclear technology has carved its own share in the world's sources of energy: according to the World Nuclear Association, sixteen nations rely on nuclear energy for at least a quarter of their energy demands. In fact, France depends on nuclear energy for 75% of its power. The country's commitment to nuclear energy began in the 1970s and 1980s, when France

[4] N.L. Char and B.J. Csik, "Nuclear Power Development: History and Outlook," IAEA, n.d., http://www.iaea.org/Publications/Magazines/Bulletin/Bull293/29304781925.pdf.
[5] "Energy Resources Today," 2004, Culverco.com, https://www.nvenergy.com/kids_conservation/more/resources.html.
[6] *Ibid*.
[7] "Oil Embargo: 1973-1974," U.S. Department of State: Office of the Historian, October 31, 2013, https://history.state.gov/milestones/1969-1976/oil-embargo.
[8] Daniel Yergin, "The Prize: The Epic Quest for Oil, Money, and Power," New York: Free Press, 1991.
[9] Susan DeFreitas, "Is Nuclear Energy a Clean Energy Source?" EarthTechling, December 23, 2010, http://earthtechling.com/2010/12/is-nuclear-power-a-clean-energy-source/.
[10] "Nuclear Power in the World Today," World Nuclear Association, April 2014, http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World-Today/.

began transitioning away from fossil fuels to nuclear energy for electricity.[11] During this time period, France observed the fastest drop in greenhouse gas emissions—a decrease of approximately 2% per year.[12] In addition, Belgium, the Czech Republic, Hungary, Slovakia, Sweden, Switzerland, Slovenia, and Ukraine use nuclear energy for one-third of their power.[13]

Before discussing individual cases that have advanced and deterred global nuclear energy development, it will first be useful to provide a succinct explanation of the process of **nuclear fission**, as well as its benefits and drawbacks, so as to pinpoint where problems may arise in the process. Enormous amounts of energy are present in the bonds that hold the nuclei of atoms together. These bonds can be broken during a process known as nuclear fission, and nuclear plants use the energy released during nuclear fission to produce electricity.[14] A common source of fuel for this process is uranium-235 because the atoms of this **isotope** are relatively easy to split apart.[15] (See Appendix A.)

Advocates of nuclear energy production claim that it is an environmentally-friendly source of power because it does not contribute to man-made climate change.[16] Nuclear energy emits low levels of carbon dioxide—the same amount as the production of hydropower and wind power do.[17] (See Appendix B.) The development of nuclear energy does not produce the environmental hazards that occurs in coal production: there is no release of carbon dioxide, sulfur, or mercury—just steam.[18,19] Fossil fuels have a notorious reputation for pouring carbon dioxide into the atmosphere.[20]

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[11] David Biello. "How Nuclear Power can Stop Global Warming." Scientific American. December 12, 2013. http://www.scientificamerican.com/article/how-nuclear-power-can-stop-global-warming/.
[12] *Ibid*.
[13] *Ibid*.
[14] "Nonrenewable Uranium (nuclear)," U.S. Energy Information Administration, n.d., http://www.eia.gov/kids/energy.cfm?page=nuclear_home-basics.
[15] *Ibid*.
[16] Bryan Walsh. "Nuclear Energy is Largely Safe. But Can it be Cheap?" *Time*, July 8, 2013, http://science.time.com/2013/07/08/nuclear-energy-is-largely-safe-but-can-it-be-cheap/.
[17] International Atomic Energy Agency, "Climate Change and Nuclear Energy," 2013, http://www-pub.iaea.org/MTCD/Publications/PDF/Pub_Climate-Change-NP-2013_web.pdf.
[18] Stewart Butler, "Nuclear Power is the True Green Energy," *The Washington Times*, January 29, 2009, http://www.washingtontimes.com/news/2009/jan/29/nuclear-power-is-true-green-energy/?page=all.
[19] Bernard L. Weinstein, "Nuclear power can bring long-term stability to the stressed electric grid," The Hill, January 15, 2014. http://thehill.com/blogs/congress-blog/energy-environment/195548-nuclear-power-can-bring-long-term-stability-to-the.
[20] Michael Totty, "The Case for and Against Nuclear Power, *The Wall Street Journal*, June 30, 2008, http://online.wsj.com/news/articles/SB121432182593500119?mg=reno64-wsj&url=http%3A%2F%2Fonline.wsj.com%2Farticle%2FSB121432182593500119.html.

With the increasing global demand for electricity—the IAEA has stated that the world's current energy production will need a 75% expansion to meet the expected demand in 2050—the amount of carbon dioxide in the atmosphere would double in the same period.[21] **Greenhouse gas (GHG) emissions** from nuclear power plants are virtually negligible, and estimates show that nuclear power can reduce GHG emissions by 15% by 2050.[22] The Intergovernmental Panel on Climate Change (IPCC) has identified nuclear power as the source of energy with the greatest potential to mitigate air pollution.[23] In contrast, fossil-based power plants are major contributors to air pollution, which cause acute and chronic respiratory problems, and the World Health Organization estimates that air pollution contributes to two million premature deaths each year.[24]

Nuclear power can also be more economical and efficient than its nonrenewable and renewable counterparts. First, nuclear energy production requires less space: a plant with two nuclear reactors may require a few hundred acres and provide energy for two million households, whereas obtaining the same quantity of energy would require the equivalent of tens of thousands of acres of wind turbines or solar panels.[25] Also, nuclear energy prices are not as volatile as oil or gas because uranium fuel is a small proportion of the generating costs of nuclear energy. Nuclear plants "refuel" on an 18-24 month cycle: one-third of the old fuel in the reactor is replaced with new fuel, and a "core shuffle" is completed to mix the fuel and maximize fuel usage efficiency.[26] Nuclear energy is a sustainable alternative energy source because millions of people in developing nations have little access to conventional sources of energy.[27] Instead of importing expensive fossil fuels, developing nations may be better supported by nuclear power plants. Moreover, advancements in uranium technology have

[21] International Atomic Energy Agency, "Nuclear Energy's Role in Mitigating Climate Change and Air Pollution," March 2013, http://www.iaea.org/Publications/Magazines/Bulletin/Bull541/54104710506.pdf.
[22] International Atomic Energy Agency, "Climate Change and Nuclear Energy," 2013, http://www-pub.iaea.org/MTCD/Publications/PDF/Pub_Climate-Change-NP-2013_web.pdf.
[23] "Nuclear Energy's Role in Mitigating Climate Change and Air Pollution," IAEA, http://www.iaea.org/Publications/Magazines/Bulletin/Bull541/54104710506.pdf.
[24] International Atomic Energy Agency, "Climate Change and Nuclear Energy," 2013, http://www-pub.iaea.org/MTCD/Publications/PDF/Pub_Climate-Change-NP-2013_web.pdf.
[25] *Ibid*.
[26] "Costs: Fuel, Operation, Waste Disposal & Life Cycle," Nuclear Energy Institute, n.d., http://www.nei.org/Knowledge-Center/Nuclear-Statistics/Costs-Fuel,-Operation,-Waste-Disposal-Life-Cycle.
[27] Joanna Burgess, "10 Pros and Cons of Nuclear Power," Discovery, n.d., http://www.discovery.com/tv-shows/curiosity/topics/10-pros-cons-nuclear-power.htm.

extended the lifetime of nuclear power plants to approximately 30-40 years, which makes a nuclear plant an economical investment.[28,29]

Because nuclear energy is economical, efficient, and carbon-friendly, it comes as no surprise that even in the aftermath of the Fukushima nuclear disaster—which will be discussed further in the next section—some nations are advancing their nuclear programs. India, which is not a member of the **Nuclear Non-Proliferation Treaty (NPT)**, has developed its own nuclear capabilities domestically and plans to increase its nuclear reactor fleet from 20 to 27. (The NPT will be discussed in detail later on.) Although India derives only 3.6% of its electricity from nuclear energy, the Atomic Energy Commission of India expects that share will increase to one-quarter by 2050.[30][31] Another country rapidly expanding its nuclear program is Sweden, which reversed a **nuclear phase-out** policy in 2010. In 1980, the Three Mile Island accident, which will be addressed in more detail later on, put pressure on the Swedish government to decommission Sweden's power plants. Nearly three decades later, Sweden's government climate program has pledged to make the country carbon-neutral by 2050. This is due in large part to Sweden's ten nuclear reactors, which provide about 40% of the country's electricity and are currently being upgraded and modernized.[32,33] Finally, the Czech Republic is in a unique position, as there is immense popular support for its nuclear energy projects. The majority of Czechs support further nuclear energy development, viewing the nuclear alternative as the only viable option to the energy crisis that will occur when the world reaches **peak oil**. Peak oil refers to the point at which half the world's oil reserves will have been extracted, which experts estimate will occur between 2010 and 2040.[34] The country's six nuclear power reactors supply more than one-third of its energy demand; plans for new reactors have stalled due to government disputes, but the

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[28] "Extending the Operational Life Span of Nuclear Plants," IAEA, February 18, 2011, http://www.iaea.org/newscenter/news/2007/npp_extension.html.
[29] "Nuclear Energy's Role in Mitigating Climate Change and Air Pollution," IAEA, http://www.iaea.org/Publications/Magazines/Bulletin/Bull541/54104710506.pdf.
[30] Harrison Jacobs, "The 17 Countries Generating the Most Nuclear Power," Business Insider, March 6, 2014, http://www.businessinsider.com/countries-generating-the-most-nuclear-energy-2014-3?op=1.
[31] "Nuclear Power in India," World Nuclear Association, September 2014, http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/.
[32] "Nuclear Power in Sweden," World Nuclear Association, September 2014, http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/Sweden/.
[33] Harrison Jacobs, "The 17 Countries Generating the Most Nuclear Power," Business Insider, March 6, 2014, http://www.businessinsider.com/countries-generating-the-most-nuclear-energy-2014-3?op=1.
[34] R.W. Allmendinger, "Peak Oil?" Cornell University Energy Studies in the College of Engineering, 2007, http://www.geo.cornell.edu/eas/energy/the_challenges/peak_oil.html.

country's commitment to furthering its nuclear energy program nonetheless continues to garner societal approval.[35,36]

Yet while nuclear energy has gathered evidence and support for being a clean, efficient, and economical energy alternative, arguments emphasizing the costs and risks of nuclear technology and incidents throughout history have raised serious questions regarding the future of nuclear energy. Costs for a nuclear reactor project often exceed initial budgets.[37] This is primarily because the upfront costs of construction are high—for example, while a natural gas power plant could cost $850/kW, a nuclear power plant would cost about $4000/kW. Thus, a nuclear power plant is often financed as an investment with interest payments, in which the interest covers the lack of certainty in construction delays, public opposition, and changes in the regulatory environment.[38] Commissioning a nuclear power plant is difficult without strict adherence to government regulations, and contractors cannot readily anticipate price shocks in construction supplies. For example, in the United States, the VC Summer site has requested budget increases seven times since 2009 in order to afford the rising costs of construction materials. Finland has pushed back construction for its largest nuclear reactor for almost a decade due to irregularities in foundation concrete (too much exposure to rain had caused the water content to exceed the amount allowed by Finnish nuclear regulators) and insufficient pipe welding (the pipes were not forged properly).[39,40]

As a result, three out of four reactors under construction around the world today are behind schedule. One primary reason for these project delays is poorly timed government-imposed regulations: some scholars contend that in the U.S., the Three Mile Island accident ushered in a regulatory response that crippled the nuclear industry and caused a wave of project delays.[41] In

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[35] *Ibid.*
[36] "Nuclear Power in Czech Republic," World Nuclear Association, August 2014, http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Czech-Republic/.
[37] "Nuclear power-an unnecessary risk," Environment Victoria, n.d., http://environmentvictoria.org.au/content/nuclear-power-unnecessary-risk#.VC9bN2ddWS0.
[38] Ian Schultz, "Basic Economics of Nuclear Power," March 19, 2012, Stanford University, http://large.stanford.edu/courses/2012/ph241/schultz2/.
[39] "Olkiluto pipe welding 'deficient', says regulator," World Nuclear News, October 16, 2009, http://www.world-nuclear-news.org/NN-Olkiluoto_pipe_welding_deficient_says_regulator-1610095.html.
[40] Alan Katz, "Nuclear Bid to Rival Coal Chilled by Flaws, Delay in Finland," *Bloomberg*, September 4, 2007, http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aFh1ySJ.lYQc.
[41] Jonathan G. Koomey, "Was the Three Mile Island accident in 1979 the main cause of US nuclear power's woes?" June 24, 2011, http://www.koomey.com/post/6868835852.

contrast, France and Japan rarely experience construction delays and overruns because they each have a streamlined government licensing and certification process.[42] Nuclear energy plants also do not generate financial returns during construction, so when there are budget shortfalls, construction projects often become delayed. Moreover, the cost of maintaining a nuclear reactor for longer than its original design basis varies significantly; according to one assessment, the range is 1.4-5.5 billion USD per reactor.[43] This cost increases each year since maintenance fees increase as reactors age.[44]

Moreover, while supporters of nuclear energy often praise it as being environmentally friendly, a recent study contends that nuclear energy's contribution to effecting climate change may only be a small sliver.[45] An MIT global growth projection estimates that the world would need 1000-1500 reactors of 1000 megawatt-electricity (MWe) capacity to truly impact the direction of climate change.[46] Achieving these numbers would require immense efforts by nations such as the United States, Russia, and Canada, which have been able to make nuclear energy lucrative by licensing technology to developing nations.[47] As a point of comparison, the United States currently has 100 nuclear reactors, but only 62 are in operation.[48]

The costs of nuclear energy extend past economic factors, and opposition to the development of nuclear energy has been fueled by financial costs and health and environmental risks associated with **radiation**. Nuclear energy reactor accidents such as the Chernobyl disaster have caused immediate and long-term health risks. While experts are unable to determine the exact number of deaths caused by the Chernobyl disaster, scientists have attributed approximately 4,000 cases of thyroid

[42] Rahul Sastry and Bennett Siegel, "The French Connection: Comparing French and American Civilian Nuclear Programs, Stanford Journal of International Relations 11 (2010): 2, https://web.stanford.edu/group/sjir/pdf/Nuclear_11.2.pdf.
[43] *Ibid*.
[44] Bryan Walsh, "Nuclear Energy is Largely Safe. But Can it be Cheap?" *Time*, July 8, 2013, http://science.time.com/2013/07/08/nuclear-energy-is-largely-safe-but-can-it-be-cheap/.
[45] "The Future of Nuclear Power," Massachusetts Institute of Technology, 2003, http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf.
[46] *Ibid*.
[47] Harrison Jacobs, "The 17 Countries Generating the Most Nuclear Power," Business Insider, March 6, 2014, http://www.businessinsider.com/countries-generating-the-most-nuclear-energy-2014-3?op=1.
[48] "How many nuclear power plants are in the U.S. and where are they located?" U.S. Energy Information Administration, April 3, 2014, http://www.eia.gov/tools/faqs/faq.cfm?id=207&t=3.

cancer to the Chernobyl fallout.[49] Nuclear disasters tend to refresh the public's safety concerns, thus harnessing the most potential to galvanize protests.

While countries have long debated the drawbacks and merits of nuclear energy, the international consensus is becoming that nuclear energy is, as an economically competitive, sustainable energy source, a strong alternative to conventional energy.[50] However, challenges remain in ensuring the safety of nuclear energy development and application. Nuclear energy programs need to consider problems such as ensuring the secure disposal of radioactive waste so it does not contaminate water supplies. High-level **radioactive waste**, the remnants of what is used to fire the nuclear reactor, is highly lethal within moments of exposure.[51] Because of radiation leaks into the surrounding environment, four of the seven sites in the United States have closed. One site was closed when the U.S. Nuclear Regulatory Commission discovered high doses of radioactive material in a nearby lake.[52] Another facility was closed permanently due to waste packaging and transportation issues; the U.S. Geological Survey also discovered radioactive waste containers placed beyond the site's boundaries.[53] The health risks associated with radiation are still present in nuclear waste, and citizen opposition to poorly managed nuclear waste sites increase costs.[54]

In the realm of nuclear technology transfer partnerships, one prominent association is the Nuclear Suppliers Group, whose membership is composed of 49 supplier states.[55] Nearly four decades after its formation, the NSG has transformed into the world's leading multilateral export control arrangement.[56] In 1978, the IAEA established the NSG Guidelines in order to ensure that transfers among members of the NSG would not put materials in the possession of nations lacking adequate security safeguards. In 1992, further guidelines were developed by the IAEA to restrict the transfer of

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[49] "Health Impacts: Chernobyl Accident Appendix 2," World Nuclear Association, November 2009, http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Appendices/Chernobyl-Accident---Appendix-2--Health-Impacts/.
[50] "The Economics of Nuclear Power," World Nuclear Association, September 2014, http://www.world-nuclear.org/info/Economic-Aspects/Economics-of-Nuclear-Power/.
[51] "Radioactive Waste," Greenpeace, n.d., http://www.greenpeace.org/usa/en/campaigns/nuclear/safety-and-security/radioactive-waste/.
[52] "United States Commerical 'Low-Level' Radioactive Waste Disposal Sites Fact Sheet," April 2009, http://www.nirs.org/factsheets/wastesitesfctst43009.pdf.
[53] *Ibid.*
[54] *Ibid.*
[55] "Nuclear Suppliers Group," NTI, n.d., http://www.nti.org/treaties-and-regimes/nuclear-suppliers-group-nsg/.
[56] Mark Hibbs, *The Future of the Nuclear Suppliers Group*, Washington D.C.: Carnegie Endowment for International Peace, 2011.

nuclear-related dual-use equipment, technology with both nuclear and non-nuclear uses.[57] However, since NSG nations partake in a large share of all global nuclear commerce, nations outside the NSG view this group as an exclusive organization and one that lacks credibility in establishing guidelines for transfers of nuclear material.

As the global demand for energy has been met with limited solutions thus far, and with a growing concern for dwindling natural energy resources, the case for nuclear energy has become increasingly more viable for economic and safety reasons.

[57] "History," Nuclear Suppliers Group, n.d., http://www.nuclearsuppliersgroup.org/en/history1.

History of the Problem

In 1938, a team of scientists consisting of Austrian physicist Lise Meitner and German chemists Otto Hahn and Fritz Straussman were the first to discover that bombarding the **nucleus** of a uranium atom would cause a vibration severe enough so as to split the atom's nucleus.[58,59] Meitner and her nephew Otto Frisch then discovered that the amount of energy released by the **nuclear fission** of a uranium or plutonium atom was equivalent to 200 million electron volts (eV).[60] Not only did these scientists discover that the fission of an atom released significant amounts of energy, but they also correctly hypothesized that the splitting of each atom would prompt a self-sustaining **chain reaction** capable of releasing tremendous levels of energy.[61] The discovery of this chain reaction marks an immense step in the development of nuclear technology, as speculation alone was the world's first look into the full potential of nuclear energy. By the 1950s and 1960s, nuclear power plants were seen as a safe, clean energy source.[62]

By the early 1900s, scientists in Germany, the then-Soviet Union, and United Kingdom were racing to determine which nation could assemble the **human and economic capital** necessary for controlling the nuclear fission chain reaction. After the global scientific community learned of the German scientists' success in splitting a uranium atom, fear that the Nazis would expand upon the research quickly spread and spurred other nations to invest in research. In 1917, the Russian Revolution increased support for scientific research, prompting an increase in the amount of financial resources allotted to nuclear research, and research centers were constructed specifically for the purpose of furthering research in physics.[63] World War II magnified the danger of nuclear energy, causing nations to focus on the militaristic application of nuclear research. Meanwhile, in the United Kingdom, two scientists hypothesized that a bomb containing five kilograms of uranium-235 could be enough to create a bomb equivalent to several thousand tons of dynamite. These scientists

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58 "Otto Hahn, Lise Meitner, and Fritz Strassmann," Chemical Heritage Foundation, n.d., http://www.chemheritage.org/discover/online-resources/chemistry-in-history/themes/atomic-and-nuclear-structure/hahn-meitner-strassman.aspx.
59 "Outline History of Nuclear Energy," World Nuclear Association, March 2014, http://www.world-nuclear.org/info/Current-and-Future-Generation/Outline-History-of-NUclear-Energy/.
60 *Ibid*.
61 *Ibid*.
62 "History of Nuclear Energy Production," Ebsco Host, n.d., http://connection.ebscohost.com/science/nuclear-power/history-nuclear-energy-production.
63"Outline History of Nuclear Energy," World Nuclear Association, March 2014, http://www.world-nuclear.org/info/Current-and-Future-Generation/Outline-History-of-NUclear-Energy/.

published a paper known as the Frisch-Peierls Memorandum, which speculated how such a bomb could be created and produced, as well as the potential effects of the explosion and radiation.[64]

Though late in joining the initial round of interest in nuclear energy, the United States quickly made progress in the development of uranium enrichment through efforts that began with the Manhattan Project, which was the name for the American project to design an atomic bomb.[65] In December 1942, Italian-American physicist Enrico Fermi led a group of physicists in producing the first **controlled nuclear chain reaction** at the University of Chicago. Funding for nuclear-related projects greatly increased after this accomplishment, as scientists sought to find ways to further harness the potential of nuclear energy.[66] The United States spearheaded efforts to produce the first commercial **pressurized water reactor**, which was established by the Westinghouse Electric Company and operated from 1960 to 1992.[67] The first **boiling water reactor** was designed by General Electric, and it was completed at the Argonne National Laboratory in 1960. (PWRs and BWRs are the two most common types of reactors. A boiling water reactor receives enough heat from the fission process to boil its own water, and has two separate water systems instead of one. LWRs are usually preferred because they are considered more cost-efficient.)[68] Also within the same decade, Canada, France, the USSR, and Kazakhstan each designed their own versions of a reactor.[69]

However, beginning in the 1970s and lasting until the turn of the new century, countries began to see stagnation in the development of nuclear energy. A major turning point was the 1986 Chernobyl disaster, an explosion at the Chernobyl Nuclear Power Plant in Ukraine that released radioactive contamination across Ukraine, Belarus, and other parts of Europe.[70] This crisis instilled fears of nuclear energy's lethal potential in people across the globe, and many began questioning if the risks outweighed the benefits. In addition, the Soviet response to the situation catalyzed a tide of political controversy: Soviet officials waited two days before reporting the accident, prompting Western

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[64] *Ibid*.
[65] "The Manhattan Project," U.S. History.org., n.d., http://www.ushistory.org/us/51f.asp.
[66] *Ibid*.
[67] "Outline History of Nuclear Energy," World Nuclear Association, March 2014, http://www.world-nuclear.org/info/Current-and-Future-Generation/Outline-History-of-NUclear-Energy/.
[68] "Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR)," Duke Energy, March 27, 2012, http://nuclear.duke-energy.com/2012/03/27/pressurized-water-reactors-pwr-and-boiling-water-reactors-bwr/.
[69] "Outline History of Nuclear Energy," World Nuclear Association, March 2014, http://www.world-nuclear.org/info/Current-and-Future-Generation/Outline-History-of-NUclear-Energy/.
[70] "Inside the Chernobyl Reactor: 25 Years Later," *Time*, n.d., http://content.time.com/time/photogallery/0,29307,2067393_2268608,00.html.

nations to accuse the Soviets of purposely concealing the incident.[71] Following the incident, survivors of the Chernobyl disaster also demanded greater transparency in nuclear emergencies.[72] The Chernobyl disaster was the first major incident that magnified what mistakes could happen with nuclear energy.

More recently, in the past two decades, developing nuclear energy has progressed forward, but at a tepid rate. The World Nuclear Industry Status Report, an annual publication that analyzes trends in nuclear power plant data, states that the nuclear energy share of the world's power generation declined from a historic peak of 17.6% in 1996 to 10.8% in 2013.[73] (See Appendix C.) Countries with newer nuclear programs, such as Bangladesh, Jordan, Lithuania, Poland, Saudi Arabia, Turkey, and Vietnam, have experienced project delays.[74] Furthermore, some nations have lessened their interest in nuclear energy due to greater success in other areas of renewable energy; in 2013, Spain was able to generate more power from wind than from any other source, including nuclear energy.[75] Looking toward the future, the Spanish government has promised a nuclear phase-out as soon as there is more certainty in wind and solar energy as alternative energy sources.[76] Spain's decision to phase out nuclear energy traces its origins back to the 1986 Chernobyl nuclear accident, which raised safety concerns throughout Europe.[77] Similarly, Italy was able to obtain 8% of its national energy production from solar energy, a significant jump from its solar energy production from just the previous year alone.[78] Other nations such as Brazil, China, Germany, India, and Japan obtain more electricity from renewable energy sources such as hydropower and wind power, which are seen as

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[71] "Chernobyl 25th Anniversary Marked By Poignant Memorial Services And Anti-Nuclear Protests," *The Huffington Post*, April 26, 2011, http://www.huffingtonpost.com/2011/04/26/chernobyl-25th-anniversary_n_853766.html#s269668title=1986.
[72] *Ibid*.
[73] Mycle Schneider and Antony Froggatt, "The World Nuclear Industry Status Report," Mycle Schneider Consulting, July 2014, http://www.worldnuclearreport.org/IMG/pdf/201408msc-worldnuclearreport2014-lr-v4.pdf.
[74] *Ibid*.
[75] *Ibid*.
[76] Harrison Jacobs, "The 17 Countries Generating the Most Nuclear Power," Business Insider. March 6, 2014, http://www.businessinsider.com/countries-generating-the-most-nuclear-energy-2014-3?op=1.
[77] "Spain-Spain Facing key decision on use of nuclear power," WikiLeaks, December 6, 2009, http://wikileaks.org/gifiles/docs/16/1672745_spain-spain-facing-key-decision-on-use-of-nuclear-power-.html.
[78] Mycle Schneider and Antony Froggatt, "The World Nuclear Industry Status Report," Mycle Schneider Consulting, July 2014, http://www.worldnuclearreport.org/IMG/pdf/201408msc-worldnuclearreport2014-lr-v4.pdf.

less risky investments with regard to human and environmental safety, as well as construction and operational costs.[79,80]

Even countries generally seen as pro-nuclear have faced political pressure to scale back ambitious projects, as evidenced by France. France is the world's largest exporter of nuclear energy and second in generating the most nuclear energy (the first is the United States). Almost 75% of its electricity comes from nuclear sources. However, Francois Hollande's election to the presidency in 2012 demonstrated that citizens wanted a change in energy policy, as a key issue of Hollande's campaign was reducing the share of electricity derived from nuclear energy from 75% to 25%.[81] During a time of budget constraints, increasing costs of updating older reactors and the Fukushima disaster imposed political pressure to reduce dependency on nuclear energy.[82]

Perhaps most discouraging to the progress of nuclear energy has been nuclear energy disasters, which have grabbed newspaper headlines, seizing public perception of nuclear energy with dramatic images and propagating fears of radiation. In particular, three nuclear-related disasters dominate discussions concerning risks associated with developing nuclear energy: the Three Mile Island accident (1979), Chernobyl disaster (1986), and Fukushima Daiichi disaster (2011). The International Nuclear and Radiological Event Scale (INES) is used to communicate the safety significance of nuclear and radiological events, similar to how the Richter scale is used to measure earthquakes. Levels 1-3 disasters are classified as incidents, and Levels 4-7 disasters are classified as accidents. The INES characterizes a Level 7 disaster (the highest rating) as having a "major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures."[83]

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[79] Juan Forero. "In Brazil, the wind is blowing in a new era of renewable energy," *The Washington Post.* October 30, 2013, http://www.washingtonpost.com/world/in-brazil-the-wind-is-blowing-in-a-new-era-of-renewable-energy/2013/10/30/8111b7e8-2ae0-11e3-b141-298f46539716_story.html.
[80] *Ibid*.
[81] Harrison Jacobs. "The 17 Countries Generating the Most Nuclear Power," Business Insider, March 6, 2014, http://www.businessinsider.com/countries-generating-the-most-nuclear-energy-2014-3?op=1.
[82] Geraldine Amiel. "France to Dim Its Reliance on Nuclear Power," *The Wall Street Journal*, June 18, 2014, http://online.wsj.com/articles/france-to-dim-its-reliance-on-nuclear-power-1403113287.
[83] International Atomic Energy Agency, "INES," n.d., https://www.iaea.org/Publications/Factsheets/English/ines.pdf.

The United States' Three Mile Island, a Level 5 disaster, was the first major nuclear-related accident.[84] In the early morning of March 28, 1979, one of the plant's two pressurized water reactors malfunctioned and automatically shut down, causing the reactor core to melt. The accident caused a release of radioactive gas into the atmosphere, although the U.S. Department of Energy reported no unusually high readings of toxic substances.[85] Moreover, a series of misunderstandings resulted in the media's misinformed distortion of the actual events, as Americans were led to believe that the Nuclear Regulatory Commission had called for an evacuation. Even though more than a dozen studies conducted on the accident concluded that there was no evidence of radiation-induced cancer, the Three Mile Island accident severely damaged public perception of nuclear energy. Many people were prone to self-induced "psychological stress" following the accident.[86] Three Mile Island prompted the birth of the anti-nuclear movement, which would temporarily swerve the direction of the U.S. nuclear industry as the nation entered what would become a long debate on the safety of nuclear energy. Ultimately, construction was postponed or suspended for 31 projects total.[87,88]

In the month following the Three Mile Island accident, approximately 100,000 activists organized a protest in Washington D.C., even garnering a field of politicians and celebrities to speak against nuclear energy during the demonstration. On the second anniversary of the Three Mile Island accident, 10,000 protestors took part in a "March on Harrisburg" that demanded the complete cessation of all nuclear activities. A year later, 75 activists burned more than $300,000 worth of unpaid electric bills as a symbolic protest against assuming financial accountability for cleanup.[89] The protestors drew considerable national attention to a fact: for political, financial, and managerial reasons, the safety of Three Mile Island had received low priority and the nuclear accident showed an obvious need for reform. Since the Three Mile Island accident, nuclear power plant designs are validated for security by more advanced computer models and undergo more rigorous testing

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[84] "Three Mile Island Accident," World Nuclear Association, January 2012, http://www.world-nuclear.org/info/safety-and-security/safety-of-plants/three-mile-island-accident/.
[85] *Ibid.*
[86] *Ibid.*
[87] Mark Lynas, "Why nuclear power is still a good choice," *Los Angeles Times*, April 10, 2011, http://articles.latimes.com/2011/apr/10/opinion/la-oe-lynas-nukes-20110410.
[88] "A Swift Rethinking of the 'Unthinkable'", *The Washington Post*, 1979, http://www.washingtonpost.com/wp-srv/national/longterm/tmi/stories/ch3.htm.
[89] "U.S. anti-nuclear activists campaign against restarting Three Mile Island nuclear generator, 1979-1985," Global Nonviolent Action Database, Swarthmore College, September 18, 2011, http://nvdatabase.swarthmore.edu/content/us-anti-nuclear-activists-campaign-against-restarting-three-mile-island-nuclear-generator-19.

procedures.[90] These procedures include accounting for smaller accidents that can galvanize the entire shutdown of a plant.

The Level 7 Chernobyl disaster, which took place on April 26, 1986, was the second major global nuclear calamity.[91] The Chernobyl reactor explosion can be attributed to inadequate operator training, flaws in the design of the reactor, and inadequate understanding and preparedness for responding to potential risks. There were two deaths at site of accident, and 28 more within a few weeks from radiation. Similar to the Three Mile Island disaster, the Chernobyl incident also resulted in extensive damage to nuclear fuel but released a relatively small amount of radiation.[92]

In addition, the Chernobyl disaster raised issues about government oversight and accountability in nuclear programs, and the incident catalyzed a tide of political controversy surrounding the Soviet response to the situation. Soviet officials waited two days before reporting the accident, prompting Western nations to accuse the Soviets of purposely concealing the incident.[93] Survivors of the Chernobyl disaster demanded greater transparency in nuclear emergencies, and the nuclear industry once more braced itself for the aftershocks of a disaster.[94]

The most recent of the three major disasters is the Fukushima Daiichi nuclear disaster, a Level 7 disaster that took place at the Fukushima Daiichi Nuclear Power Station in Japan on March 11, 2011.[95] The disaster was triggered when a power plant was hit by an earthquake and tsunami; it resulted in fuel melting and large quantities of radioactive material released into the environment. The disaster resulted in large-scale consequences: the disaster displaced more than 300,000 residents (200,000 of them permanently). Moreover, the Japanese government first estimated that

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[90] Rod Adams, "What Did We Learn from Three Mile Island?" March 25, 2014, http://ansnuclearcafe.org/2014/03/25/what-did-we-learn-from-three-mile-island/.
[91] "Chernobyl Accident 1986," World Nuclear Association, April 2014, http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Chernobyl-Accident/.
[92] Richard Rhodes, *Nuclear Renewal: Common Sense About Energy*, New York: Viking Penguin, 1993, http://www.pbs.org/wgbh/pages/frontline/shows/reaction/readings/chernobyl.html.
[93] "Chernobyl 25th Anniversary Marked By Poignant Memorial Services And Anti-Nuclear Protests," *The Huffington Post*, April 26, 2011, http://www.huffingtonpost.com/2011/04/26/chernobyl-25th-anniversary_n_853766.html#s269668title=1986.
[94] *Ibid*.
[95] James M. Acton and Mark Hibbs, Why Fukushima Was Preventable," The Carnegie Endowment for International Peace, March 2012, http://carnegieendowment.org/files/fukushima.pdf.

the amount of radiation released was 15% that of the Chernobyl disaster; the exact quantity of radiation has not yet been determined.[96]

To ensure a timely and full response to the Fukushima disaster, the Ministerial Conference on Nuclear Safety in June 2011 asked the IAEA to prepare an Action Plan on Nuclear Safety; this plan consisted of 12 actions total and was adopted by the IAEA in September of the same year.[97] The key points of the plan were as follow: first, to "review and strengthen emergency preparedness;" secondly, to "tighten cooperation for monitoring, decontamination, and mediation, especially for the removal of damaged nuclear fuel and the disposal of radioactive waste;" and finally, to "increase research and development related to protecting facilities against extreme natural hazards, severe accidents, and post-accident monitoring systems."[98]

The consequences of Fukushima were felt worldwide: nations such as Germany leaned closer toward a nuclear phase-out—Switzerland decided to terminate its plans for new nuclear reactors in addition to remove its five operating reactors from service by 2035.[99] Germany shut down eight plants in the aftermath of Fukushima, increased renewable energy generation, and made plans to open nine new coal plants.[100] It is important to note that Germany's coal projects are not reflective of a trend toward increased coal consumption, but rather that renewable energy has offset the shutdown of nuclear power plants.[101]

Could the Fukushima disaster have been prevented? Some experts, including scientists James Acton and Mark Hibbs, argue that the plant could have been secured so it would not have been inundated by a massive tsunami.[102] The following measures could have been put in place: protecting

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[96] *Ibid*.
[97] International Atomic Energy Agency, "IAEA Plan on Nuclear Safety," https://www.iaea.org/newscenter/focus/actionplan/reports/actionplanns130911.pdf.
[98] International Atomic Energy Agency, "Climate Change and Nuclear Power 2012," 2012, http://www.iaea.org/OurWork/ST/NE/Pess/assets/12-44581_ccnp2012_web.pdf.
[99] Harrison Jacobs, "The 17 Countries Generating the Most Nuclear Power," Business Insider, March 6, 2014, http://www.businessinsider.com/countries-generating-the-most-nuclear-energy-2014-3?op=1.
[100] Robert Wilson, "Why Germany's Nuclear Phase Out is Leading to More Coal Burning," The Energy Collective, January 20, 2014, http://theenergycollective.com/robertwilson190/328841/why-germanys-nuclear-phase-out-leading-more-coal-burning.
[101] Arne Jungjohann and Craig Morris, "The German Coal Conundrum," June 17 2014, http://energytransition.de/2014/06/german-coal-conundrum/.
[102] James M. Acton and Mark Hibbs, "Fukushima Could Have Been Prevented," *The New York Times*, March 9, 2012, http://www.nytimes.com/2012/03/10/opinion/fukushima-could-have-been-prevented.html.

emergency power supplies (diesel generators and batteries) by moving them to higher ground or in watertight bunkers, establishing watertight connections between emergency power supplies and key safety systems, and protecting the seawater pumps that were used to transfer heat from the plant to the ocean, (for the purpose of cooling the diesel generators).[103] The nuclear disasters at Fukushima, Three Mile Island, and Chernobyl offer stark insights into what the world needs for a safe and sustainable nuclear future—critical lessons that undoubtedly promise worse disasters if we do not learn from the past.

[103] James M. Acton and Mark Hibbs, "Fukushima Could Have Been Prevented," *The New York Times*, March 9, 2012, http://www.nytimes.com/2012/03/10/opinion/fukushima-could-have-been-prevented.html.

Past Actions

Under the Nuclear Non-Proliferation Treaty, the IAEA has a safeguards system in which it promotes cooperation between nations in developing energy for peaceful purposes, as well as implementing safeguards to achieve nuclear **nonproliferation**. Once a nation has the capacity to develop nuclear energy, it is extremely close to having the potential for developing nuclear weapons: nuclear reactors produce uranium and plutonium, which can be enriched at the same facilities to weapons-grade material. Nonproliferation is the curbing of access to material that can be used to form nuclear weapons. The IAEA monitors the flow of nuclear material between facilities, physical security, and containment and surveillance.[104] The agency conducts routine inspections to verify the information submitted by the NPT signatories.[105]

Perhaps the most cited document in the history of nonproliferation is the Nuclear Non-Proliferation Treaty (NPT), which was completed in 1968 and outlined four primary objectives.[106] The NPT was designed to stop the spread of nuclear weapons, to provide security for non-nuclear weapons states that had renounced interest in nuclear capabilities, to encourage international cooperation for the peaceful uses of nuclear energy, and lastly, to gradually work toward the complete elimination of nuclear weapons. In 1995, this agreement was renewed indefinitely. Today, 189 states and Taiwan have acceded to the NPT.

While the NPT entered into effect in 1970, the rights guaranteed to nations in this document have been subject to a higher level of scrutiny with regard to its interpretation and application in recent years.[107,108] Article IV of the NPT states, "All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific

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104 "Safeguards to Prevent Nuclear Proliferation," World Nuclear Association, September 2014, http://www.world-nuclear.org/info/Safety-and-Security/Non-Proliferation/Safeguards-to-Prevent-Nuclear-Proliferation/.
105 *Ibid*.
106 "Safeguards to Prevent Nuclear Proliferation," World Nuclear Association, June 2014, http://www.world-nuclear.org/info/Safety-and-Security/Non-Proliferation/Safeguards-to-Prevent-Nuclear-Proliferation/.
107 Dan Joyner, "Scope, Meaning, and Juridical Implication of the NPT Article IV (1) Inalienable Right," November 7, 2013, http://armscontrollaw.com/2013/11/07/scope-meaning-and-juridical-implication-of-the-npt-article-iv1-inalienable-right/.
108 Giorgio Franceschini, The NPT Review Process and Strengthening the Treaty: Peaceful Uses." EU Non-Proliferation Consortium, *Non-Proliferation Papers* 11 (2012), http://www.sipri.org/research/disarmament/eu-consortium/publications/non-proliferation-paper-11.

and technological information for the peaceful uses of nuclear energy."[109] There is not only an increase in the number of nations interested in developing domestic energy programs, but also more industrialized nations simultaneously questioning the intentions of nations entering the nuclear energy scene.[110] For example, Iran has frequently referenced Article IV of the NPT when confronted with accusations about violating IAEA safeguards. A longtime enemy of Iran, Saudi Arabia has been deeply concerned about Iran's nuclear capabilities and announced in June 2011 plans to develop sixteen nuclear reactors in the next two decades. Should Saudi Arabia gain the capacity to develop its own robust nuclear program, it may only further destabilize the fragile relations in the Middle East.[111] In general, the NPT discusses the players involved in nuclear energy as the Nuclear Weapons States (NWS) and Non Nuclear Weapons States (NNWS); the document states that it is a right for all countries to share in the "blessings" of nuclear energy. The imbalance of nuclear technology possession in today's world reflects a reality unrepresentative of the NPT's intended direction.[112]

At the 2010 Review Conference for the Treaty on the Non-Proliferation of Nuclear Weapons (2010 NPT RevCon), the topic of peaceful uses of nuclear energy took center stage during discussion and even received greater attention than nuclear disarmament and non-proliferation.[113] This conference reiterated each party's right to "full access to nuclear material, equipment and technological information for peaceful purposes" and reaffirmed each nation's right to the "fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy."[114]

Article IV of the NPT, which touches upon the Nuclear Suppliers Group and the exchange of sensitive nuclear technology, has caused a stir of controversy. On one end of the spectrum, "non-proliferators" call for a restrictive policy on the flow of **uranium enrichment** and **plutonium reprocessing technologies (ENR)**, and believe that nations with access should follow strict

[109] "The Treaty on The Non-Proliferation of Nuclear Weapons," 2000, http://www.un.org/en/conf/npt/2005/npttreaty.html.
[110] *Ibid*.
[111] Jason Burke, "Riyadh will build nuclear weapons if Iran gets them, Saudi prince warns," *The Guardian*, June 29, 2011, http://www.theguardian.com/world/2011/jun/29/saudi-build-nuclear-weapons-iran.
[112] Giorgio Franceschini, The NPT Review Process and Strengthening the Treaty: Peaceful Uses." EU Non-Proliferation Consortium, *Non-Proliferation Papers* 11 (2012), http://www.sipri.org/research/disarmament/eu-consortium/publications/non-proliferation-paper-11.
[113] *Ibid*.
[114] "2010 NPT Review Conference Action Plan," n.d. http://www.reachingcriticalwill.org/images/documents/Disarmament-fora/npt/revcon2010/2010NPTActionPlan.pdf.

limitations on their domestic fuel cycles.[115] On the other end, a group of nations known as the Non-Aligned Movement (NAM), a group organized to "create an independent path in world politics that would not result in member states becoming pawns in the struggles between the major powers," stresses the inalienable right in the NPT for all parties to pursue peaceful applications of nuclear energy, and the cooperative obligation of the NWS to aid the NNWS in developing domestic programs with the "fullest possible exchange." [116,117] Striking a middle ground has been a point of focus in recent RevCons, but still has not been sufficiently addressed.

In the 1980s, Iran and Iraq had demonstrated a critical flaw in the NPT: both parties had acceded to the NPT, but both established undeclared facilities to enrich uranium.[118] Concern regarding undeclared nuclear activities led to the development of the Additional Protocol in 1993, which widened the IAEA's jurisdiction to monitor more materials (uranium and thorium, even if that materials are not used for trade) and allow IAEA personnel greater accessibility in conducting inspections.[119]

A model example of a nation that has rapidly made progress in developing its nuclear capacity for peaceful purposes is China, which has 20 nuclear reactors currently in operation and 29 ongoing construction.[120] The appeal of nuclear energy is two-fold: the nation relies heavily on coal for power, and poor air quality makes nuclear energy an eco-friendly investment.[121] China has used technology from France, Russia, and the United States as the foundation for its own program; now, China has

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[115] Giorgio Franceschini, The NPT Review Process and Strengthening the Treaty: Peaceful Uses." EU Non-Proliferation Consortium, *Non-Proliferation Papers* 11 (2012), http://www.sipri.org/research/disarmament/eu-consortium/publications/non-proliferation-paper-11.
[116] "Non-Aligned Movement," Nuclear Threat Initiative, n.d., http://www.nti.org/treaties-and-regimes/non-aligned-movement-nam/.
[117] Giorgio Franceschini, The NPT Review Process and Strengthening the Treaty: Peaceful Uses." EU Non-Proliferation Consortium, *Non-Proliferation Papers* 11 (2012), http://www.sipri.org/research/disarmament/eu-consortium/publications/non-proliferation-paper-11.
[118] "Safeguards to Prevent Nuclear Proliferation," World Nuclear Association, September 2014, http://www.world-nuclear.org/info/Safety-and-Security/Non-Proliferation/Safeguards-to-Prevent-Nuclear-Proliferation/.
[119] *Ibid*.
[120] International Atomic Energy Agency, "Nuclear Power Reactors in the World, 2014, http://www-pub.iaea.org/books/IAEABooks/10756/Nuclear-Power-Reactors-in-the-World-2014-Edition.
[121] Giorgio Franceschini, The NPT Review Process and Strengthening the Treaty: Peaceful Uses." EU Non-Proliferation Consortium, *Non-Proliferation Papers* 11 (2012), http://www.sipri.org/research/disarmament/eu-consortium/publications/non-proliferation-paper-11.

the capability to profit by selling its technology to other nations.[122] First on the list of customers is Pakistan with a purchase of an advanced Chinese model. China has also made plans to operate power plants in the United Kingdom, and the Chinese government is looking to partner with Turkey, Brazil, South Africa, and Argentina. While most people do not doubt China's financial capabilities, China has yet to convince Western nations of the safety of its reactors.[123]

[122] Zhang Yangpeng, "Foreign nuclear deals 'on way,'" *China Daily*, March 8, 2013, http://europe.chinadaily.com.cn/business/2013-03/08/content_16290428.htm.

[123] Gordon G. Chang, "Will China Export the Next Chernobyl?," *Forbes*, June 22, 2014, http://www.forbes.com/sites/gordonchang/2014/06/22/will-china-export-the-next-chernobyl/.

Possible Solutions

Is nuclear energy the energy option for nations to pursue? How do we make nuclear energy accessible to all nations that abide by IAEA safeguard obligations? Ultimately, this question should be addressed in two parts: first, opening international nuclear commerce to nations seeking to develop peaceful uses of nuclear technology and ensuring that all nations which are given access to nuclear technology commit to using it for peaceful purposes; and second, successfully implementing and developing civil nuclear energy programs. Although countries differ because of their varied energy growth demands, availability of alternative energy options, and financing options, investing in nuclear energy can still be a viable option with stable government policies, the safe regulatory mechanisms, and proper safeguards against risk.[124]

This committee will also need to address the role of the Nuclear Suppliers Group, which has urgent cause to reach out to nations outside its current membership. Policy recommendations for the NSG could include drafting and adopting a Code of Conduct for suppliers to reinforce nonproliferation, and creating a mechanism for implementing the guidelines in order to discourage "guideline shopping" by proliferators (that is, prevent nations from taking advantage of countries with breaches in export control arrangements).

Additionally, the NSG coexists with other arrangements dealing with **Weapons of Mass Destruction (WMDs)**: these organizations include the Australia Group, the Missile Technology Control Regime, and the Wassenaar Arrangement. Each group is active in adopting new measures and practices for technologies. The groups have also received criticism for acting as "cartels meant to shelter established technology holders and exporters." Generally, the IAEA should foster collaboration among the NSG and other arrangements, such as by establishing a permanent working group to jointly respond to challenges common to all parties involved such as data security, threat assessments, and incidents of noncompliance.[125]

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[124] H-Holger Rogner, "Energy Planning and Application to Nuclear Power," IAEA, 2011, http://www.iaea.org/NuclearPower/Downloadable/Meetings/2011/2011-May-Africa/EnergyPlanningApplications-H.Rogner-IAEA.pdf.

[125] *Ibid*.

The existence of groups such as the NSG enable the trade of nuclear materials that leave nations responsible for their own exchanges, which may result in precarious scenarios if stakeholders do not uphold safety or security regulations. For example, there may be pressure for a nation to act as a supplier for another nation lacking the proper infrastructure to safely house nuclear materials. A 2011 IAEA publication notes the existence of an alarming pattern in the timing of when nations develop nuclear safeguards: safeguards are often introduced following construction freezes.[126] The IAEA provides legal assistance, technical support, guidance publications, and personnel training services. Nations should establish regulations for physical security: areas of focus include plant layout and design, component design, decontamination, shielding, ventilation, and storage. In addition, nations must take into account environmental safeguards, as well as measures for radiological protection and waste management and disposal. Countries should also develop timeframes for updating and improving existing reactors to ensure older reactors are up-to-date with safety standards and operate at or close to maximum efficiency.

Lastly, delegates will need to formulate solutions for the financing of civil nuclear projects. Public opinion is unlikely to embrace expanding nuclear power programs without significant improvements in cost or technology. According to a recent study conducted by researchers at MIT, even in the United States, a nation seen as one of the leaders in nuclear energy, people do not link global warming concerns with carbon-free nuclear power—the tasks of how to reduce cost and risk remain obstacles to increased investment.[127] Following the 2008 global financial crisis and Fukushima disaster, increased financial protection for investors also surfaced as a necessity for continued investment. Moving away from traditional route of financing their own national nuclear programs, governments may find increasing industry and private sector participation to be a beneficial alternative route.

Faced with a soaring demand for electricity across the globe, and in the midst of a globalized environment in which nuclear goods can be produced or transacted anywhere in the world, delegates in this session of the IAEA must make watershed decisions for how to build nuclear

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[126] Rebecca Stevens, "Early Capacity Building for Safeguards," IAEA, February 2011, http://www.iaea.org/NuclearPower/Downloadable/Meetings/2011/2011-02-TM-WS-Vienna/Day-3/Stevens_IAEA.pdf.
[127] "The Future of Nuclear Power," Massachusetts Institute of Technology, 2003, http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf.

capacity in nations that adhere to good practices.[128] In improving or replacing policies that currently govern the state of nuclear affairs, members of the IAEA must balance the interests of individual countries with those of the greater international community, especially when these interests collide.

[128] Mark Hibbs, *The Future of the Nuclear Suppliers Group*, Washington D.C.: Carnegie Endowment for International Peace, 2011.

Bloc Positions

Countries with Nuclear Reactors that Have Scaled Back Nuclear Energy Reliance: *Belgium, Croatia, Germany, Japan, Mexico, Slovenia, South Africa, Spain, Switzerland*

This bloc is composed of countries that have existing nuclear reactors for the purpose of civilian nuclear energy,[129] but are not likely to pursue further nuclear energy projects in the future.[130] Spain, for example, imposed a moratorium on nuclear reactors in 1983, thus banning further construction, and Belgium aims to close its nuclear reactors beginning in 2015.[131] In the wake of the 2011 Fukushima nuclear disaster, Japan has signalled an intention to decrease its reliance on nuclear energy; Germany closed down eight reactors in response to this disaster, with the remaining facilities scheduled for closure by 2022, and Switzerland banned future nuclear plant construction in this same aftermath.[132] Mexico has scrapped plans to construct more nuclear plants, instead shifting its focus to fossil fuel facilities.[133] While South Africa, Croatia, and Slovenia (Croatia and Slovenia have a shared power plant) similarly have no plans to build more nuclear plants, their policies stem most directly from a lack of resources and interest.[134]

Countries with Nuclear Reactors Aiming to Further Expand Capabilities: *Argentina, Armenia, Brazil, Bulgaria, Canada, China, People's Republic of, Czech Republic, Finland, France, Hungary, India, Iran, Korea, Republic of, Netherlands, Pakistan, Romania, Russian Federation, Slovakia, Sweden, Ukraine, United Kingdom, United States of America*

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[129] "World Nuclear Power Plants in Operation," *Nuclear Energy Initiative*, last modified April 2014, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/World-Statistics/World-Nuclear-Power-Plants-in-Operation

[130] "Nuclear Units Under Construction Worldwide," *Nuclear Energy Institute*, last modified April 2014, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/World-Statistics/Nuclear-Units-Under-Construction-Worldwide

[131] "Nuclear Europe: Country Guide," *BBC News*, April 15, 2009, http://news.bbc.co.uk/2/hi/europe/4713398.stm

[132] Scott Sayare, "Wishing Upon an Atom in a Tiny French Village," *The New York Times*, February 2, 2012, http://www.nytimes.com/2012/02/03/world/europe/wishing-upon-an-atom-in-a-tiny-french-village.html?pagewanted=all&_r=0

[133] "Nuclear Power in Mexico," *World Nuclear Association*, last modified October 2013, http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Mexico/

[134] "Emerging Nuclear Energy Countries," *World Nuclear Association*, last modified October 2014, http://world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/

This bloc is composed of countries that are already using nuclear energy from their own power plants[135] and intend to further develop their nuclear energy capabilities, undeterred by incidents like the 2011 Fukushima disaster.[136] It is important to note that most of these countries have large populations—in fact 6 of these countries rank among the 10 countries with the highest populations in the world[137]—and thus their energy needs may be higher than most other countries. Furthermore, these countries have the necessary resources to expand their programs, and most have long established nuclear reactor programs.[138]

Countries without Nuclear Reactors that Plan to Pursue Nuclear Energy: *Azerbaijan, Bahrain, Bangladesh, Belarus, Bolivia, Ecuador, Estonia, Georgia, Indonesia, Jordan, Kazakhstan, Kenya, Latvia, Malaysia, Mongolia, Morocco, Namibia, Peru, Philippines, Poland, Qatar, Saudi Arabia, Senegal, Serbia, Singapore, Sri Lanka, Sudan, Thailand, Turkey, Uganda, United Arab Emirates, Viet Nam, Yemen*

This bloc is composed of emerging nuclear energy countries,[139] which is a term used to describe countries that do not currently have functioning nuclear reactors, but are pursuing plans to develop nuclear reactors for the purposes of civilian energy. The countries in this group include both developing nations and sophisticated economies. They are all at varying stages of progress, but the fastest emerging are United Arab Emirates, Turkey, Vietnam, Belarus, Poland, and Jordan.[140] In Belarus and the United Arab Emirates, reactors are already under construction, while Lithuania and Turkey have signed contracts to authorize new construction and have established the necessary legal and regulatory infrastructure to implement these initiatives.[141] Vietnam, Jordan, Poland, and Bangladesh have committed to plans and are currently developing the necessary infrastructure, while Thailand, Indonesia, Egypt, Kazakhstan, Saudi Arabia, and Chile have well-developed plans but

[135] "World Nuclear Power Plants in Operation," *Nuclear Energy Initiative*, last modified April 2014, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/World-Statistics/World-Nuclear-Power-Plants-in-Operation
[136] "International Status and Prospects for Nuclear Power 2014," *IAEA*, August 4, 2014, pg. 5, http://www.iaea.org/About/Policy/GC/GC58/GC58InfDocuments/English/gc58inf-6_en.pdf
[137] "2014 World Population Data Sheet," *Population Reference Bureau*, 2014, http://www.prb.org/pdf14/2014-world-population-data-sheet_eng.pdf
[138] José Goldemberg, "Nuclear energy in developing countries," *American Academy of Arts and Sciences*, 2009, https://www.amacad.org/content/publications/pubContent.aspx?d=860
[139] "Emerging Nuclear Energy Countries," *World Nuclear Association*, last modified October 2014, http://world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/
[140] Ibid.
[141] Ibid.

have not yet made commitments to carry them out.[142] Nigeria, Kenya, Malaysia, and Morocco are currently developing nuclear reactor plans, while the remaining countries are at the stage of discussing such actions as a serious policy option.[143] This move towards nuclear energy is driven by the trend of urbanization and the increasing demand for electricity. These countries are likely to look to the IAEA and countries that already have nuclear programs in place for assistance in developing their own programs.

Countries without Nuclear Reactors that Have Chosen Not to Pursue Nuclear Energy: Australia, Austria, Denmark, Egypt, Greece, Iceland, Iraq, Ireland, Israel, Italy, Kuwait, Luxembourg, New Zealand, Norway, Oman, Portugal

This bloc is composed of countries that do not have nuclear reactors and are not entertaining the development of nuclear energy as a policy option.[144] Their disinclination to pursue nuclear energy arises from an appreciation of the dangers of nuclear energy and a reluctance to take on the necessary risks, particularly the risk that nuclear energy could develop into nuclear weaponry. Notably, Italy has in the past pursued nuclear energy and operated reactors of its own, but in recent times has moved to shut down these facilities.[145] Many others members of this bloc, such as Venezuela and Israel, once had declared intentions to pursue nuclear energy, but reversed these policies in the aftermath of the Fukushima nuclear disaster in Japan in 2011.[146]

Countries without Nuclear Reactors that Lack the Capability to Pursue Nuclear Energy: *Afghanistan, Albania, Algeria, Angola, Bahamas, Belize, Benin, Bosnia and Herzegovina, Botswana, Brunei, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Chile, Colombia, Congo, Democratic Republic of Congo, Republic of, Costa Rica, Cuba, Cyprus, Côte d'Ivoire, Dominican Republic, El Salvador, Eritrea, Ethiopia, Fiji, Gabon, Ghana, Guatemala, Haiti, Honduras, Jamaica, Kyrgyzstan, Laos, Lebanon, Lesotho, Liberia, Libya, Liechtenstein, Lithuania, Macedonia, Former*

[142] Ibid.
[143] Ibid.
[144] "Emerging Nuclear Energy Countries," *World Nuclear Association*, last modified October 2014, http://world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/
[145] "Nuclear Power in Italy," *World Nuclear Association*, July 2014, http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Italy/
[146] Stephanie Cooke, "After Fukushima, Does Nuclear Power Have a Future?" *The New York Times*, October 10, 2011, http://www.nytimes.com/2011/10/11/business/energy-environment/after-fukushima-does-nuclear-power-have-a-future.html?pagewanted=all

Yugoslav Republic of, Madagascar, Malawi, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Moldova, Monaco, Montenegro, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Palau, Panama, Papua New Guinea, Paraguay, Rwanda, San Marino, Seychelles, Sierra Leone, Swaziland, Syrian Arab Republic, Tajikistan, Tanzania, Togo, Trinidad and Tobago, Tunisia, Uruguay, Uzbekistan, Venezuela, Zambia, Zimbabwe

This bloc is best described as the group of countries that does not have nuclear reactors and does not intend to build any.[147] Members of this bloc are predominantly developing countries that most likely do not have the necessary resources, infrastructure, or the economic demand to viably pursue nuclear energy. As such, these countries rely almost exclusively on fossil fuels and other non-nuclear sources of energy.

[147] "World Nuclear Power Plants in Operation," *Nuclear Energy Initiative*, last modified April 2014, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/World-Statistics/World-Nuclear-Power-Plants-in-Operation

Glossary

Boiling water reactor (BWR): one of the two types of nuclear reactors. This type of reactor converts the water to steam by using fission to heat the water. The steam turns the generator and can be recycled back into the process after use.

Chain reaction: a multistage chemical reaction during which one event triggers another event

Greenhouse gas (GHG): a gas that absorbs infrared radiation and traps and contains heat in the atmosphere

Human and economic capital: the value of the skills, knowledge, and experience possessed by an individual or population

Isotope: an atom of an element with an equal number of protons but different numbers of neutrons in their nuclei

Nonproliferation: the prevention of the spread of nuclear weapons

Nuclear fission: a nuclear reaction in which the nucleus of an atom splits either spontaneously or upon contact with another particle, releasing tremendous amounts of energy

Nuclear Non-Proliferation Treaty (NPT): A 1968 document with provisions to stop the spread of nuclear weapons, to provide security for non-nuclear weapons states that had renounced interest in nuclear capabilities, to encourage international cooperation for the peaceful uses of nuclear energy, and to gradually work toward the complete elimination of nuclear weapons

Nuclear phase-out: termination of using nuclear power as a source of energy

Nucleus: the core of an atom that is composed of neutrons and protons

Peak oil: the point at which half the world's oil reserves will have been extracted

Pressurized water reactor (PWR): one of the two types of nuclear reactors. This type of reactor keeps water under pressure to increase the water's temperature but does not reach boiling.

Plutonium reprocessing technology: chemical separation technologies that separate plutonium from nuclear fuel

Radiation: energy emitted as particles or waves

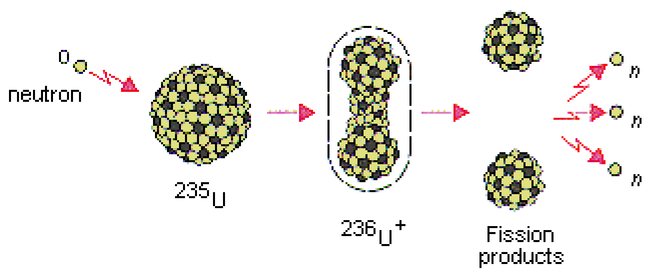
Radioactive waste: uranium fuel that can no longer be used in a power reactor (usually after three years of use in generating heat for electricity)

Uranium enrichment: the process in which a sample of uranium has its proportion of uranium-235 increased. This process is completed through centrifugion or newer methods such as laser techniques.

Weapons of Mass Destruction (WMDs): any weapon (chemical, nuclear, biological) that has the potential to inflict massive harm to people and damage to the environment

Appendix A

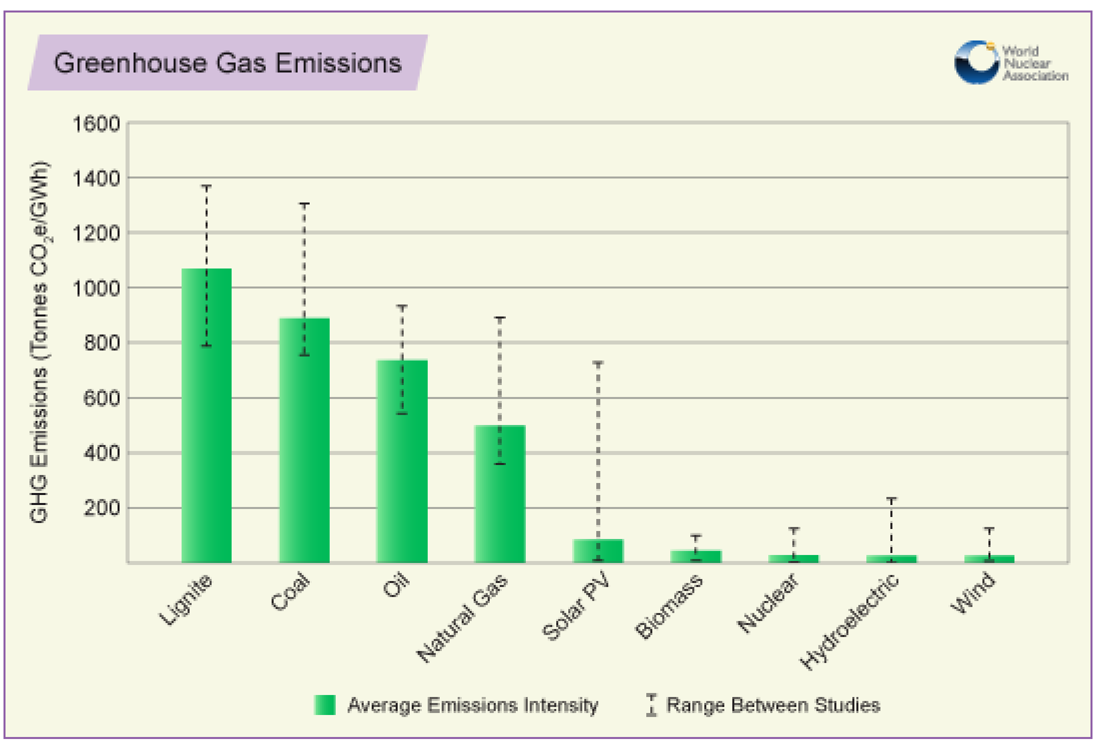
Nuclear Fission



Source: http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch23/fission.php

Appendix B

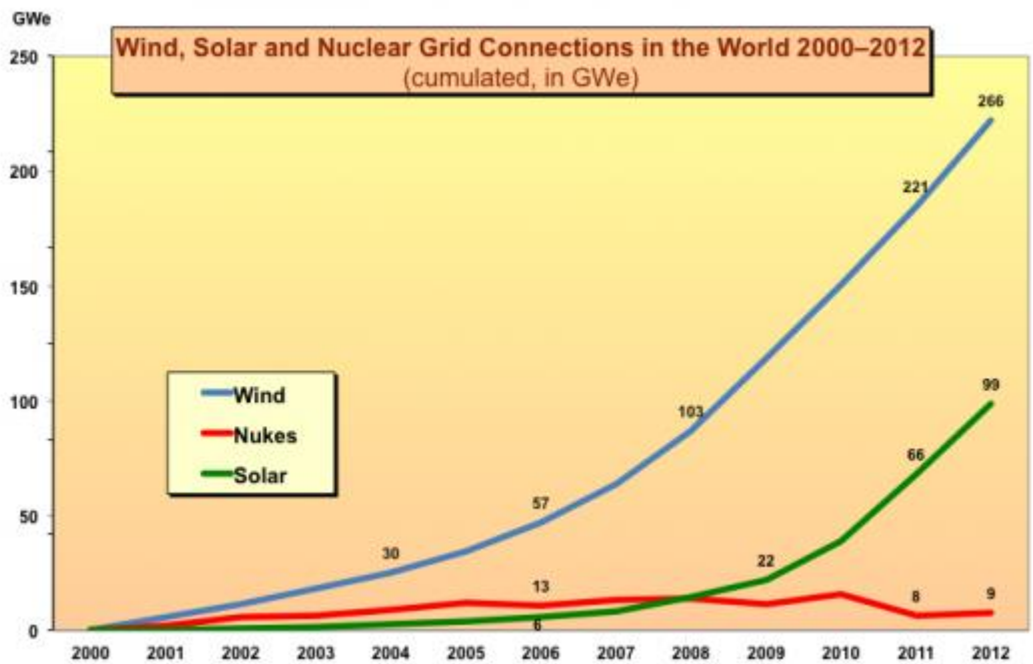
Greenhouse Gas Emissions for Varying Sources of Energy



Source: http://www.world-nuclear.org/Nuclear-Basics/Greenhouse-gas-emissions-avoided/

Appendix C

Energy Production



Source: http://cleantechnica.com/files/2014/04/electricity-capacity-world.png

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