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The Political Economy of Nuclear Energy: Why there is not broad public support for nuclear policy & why there should be

Willa Grace Mei Lee
Western Washington University

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Advised by Dr. Brandon Dupont

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Abstract

In this paper, I examine how the nuclear incidents at Three Mile Island, Chernobyl, and Fukushima impacted public support for nuclear energy in the United States. Particularly, I look at the ways the media has influenced public perception, and thus, nuclear policy. I also consider the economic arguments for and against using nuclear power and highlight the effects of decommissioning nuclear fleets as was seen in the aftermath of the major nuclear incidents. Lastly, I discuss how the public can become better informed on nuclear energy.

Ultimately, the three major nuclear incidents spurred anti-nuclear sentiment, which shut down nuclear plants, created distrust in the government, and stalled progress for a nuclear waste storage site. The media gave way to an abundance of confusion and fear, leading to reactive nuclear policy. Unlike renewable energy sources, nuclear energy has high capital costs and unfavorable employment. However, it is a reliable baseload energy source and pays workers higher salaries comparatively. Additionally, decommissioning nuclear plants led to an increase in fossil fuel production, which increased mortality due to air pollution and higher electricity prices. This forces one to consider the true impacts of these well-intentioned, but fear-based policies.

Through my research, I propose that technical writers need to be hired to cover the highly complex issue of nuclear energy. Furthermore, it is essential to research the gender gap and study the Knowledge Deficit Model in order to understand the lack of public support and find ways to overcome it. Lastly, in order to find solutions to the current challenges of nuclear energy, America must commit to investing in nuclear research and development. I come to understand that it may be time to reconsider the role of nuclear energy in the United States in order to achieve our emission goals. Although there is risk in utilizing nuclear energy, the risk of not pursing this carbon-free source may be greater.

Introduction

Over the past few decades, the world has seen the impact of climate change and has begun to acknowledge the growing need to act quickly in order to slow down increasing temperatures. At the same time, American society feels the need to have electricity available at the flick of a light switch. As the push for a cleaner environment continues with a goal to lower carbon emissions, nuclear energy has great potential to help achieve that goal. Yet, the use of nuclear energy comes with much political resistance. The negative perception stems from various sources, including from the media which portrays nuclear energy largely in a calamitous light. The media has the ability to alter personal values and individual decision-making, ultimately leading to a collective opposition to nuclear power and instead, opting to use more fossil fuels. All the while, nuclear energy has favorable outcomes for the environment, with zero carbon emissions, and is a reliable baseload energy source. Ultimately, while nuclear energy is not risk-free, it is an energy source that can help achieve America's climate change goals as long as there is an emphasis on educating the public, studying the gender gap, and investing in nuclear research and development.

Climate Change and Renewable Energy

The damage done by climate change is growing. Climate change means rising sea levels, ocean acidification, extreme weather events, and warming temperatures among many other consequences. Nearly all in the scientific community have come to the conclusion that these climate-warming trends, particularly the increased release of CO_2 which traps heat inside our atmosphere, are due to human activity (National Aeronautics and Space Administration). This overproduction of CO_2 can partially be attributed to American energy markets, particularly from coal-fired power plants. In 2019, CO_2 emissions amounted to 1,524 million metric tons with coal-fired power plants contributing 952 million of those metric tons (United States Energy Information Administration [EIA], n.d.a). Overall, in 2018, the energy sector produced 27% of total U.S. greenhouse gas emissions (United States Environmental Protection Agency).

Furthermore, the social cost of climate change is high; the Obama administration estimated this social cost to be $50 per ton of CO_2 in 2019. This cost includes the "losses (or gains in northern climates) to agriculture caused by global warming, flooding from sea level rise, and destruction from more-severe tropical cyclones and additional wildfires" (Gillingham, 2019, paras. 9). Some experts even argue the social cost is closer to $75 dollars per ton of CO_2. Fortunately, there are many methods of carbon reduction that are less costly than the supposed $50 and $75 dollar social cost. "If this $75 estimate is used instead of $50, advanced nuclear becomes another option that is less expensive than carbon's social cost" (Gillingham, 2019, paras. 10). Clearly, as the effects of climate change continue to worsen, there needs to be a way to produce electricity with fewer greenhouse gas pollutants. This need can be fulfilled by switching to renewable energy, such as wind, solar, and nuclear.

As the repercussions of climate change continue to grow, so does America's use of renewable energy. In the last decade, there has been considerable growth in the wind and solar industries with long-term projections expecting them to produce 80% of the total generation coming from renewables by 2050 (EIA, 2020b). Given the prosperous future of solar and wind, many argue they are better environmentally-friendly sources of energy. Yet, their share of total generation is still minute today, with solar contributing 1.7% of generation and wind contributing 7.1% of generation in 2019, compared to nuclear which produces 20% (EIA, n.d.b). Furthermore, by 2050, renewables will only contribute 38% of total electricity (EIA, 2020b).

While solar and wind are less controversial sources than nuclear, there are many issues with scaling up their use.

The primary problem is their intermittent nature, which prevents them from becoming reliable baseload plants that are able to provide a sizable amount of the electricity demanded. Solar can only produce electricity during the day and when the sun is shining while wind can only produce when it is windy, which occurs more frequently at night when electricity demand is lower. Their intermittent nature results in the need for supplemental backup plants that can ramp up or down quickly and do not depend on having the correct environmental conditions. In addition, there is the difficulty system operators experience with these renewables while balancing the energy market due to their unpredictability. Moreover, solar and wind plants tend to be located in remote locations, which increase transmission costs that may be passed on to the consumer. Ultimately, while solar and wind are some of the most environmentally-friendly sources, there are concerns with the economic and political viability of scaling them up.

The Politics

While solar and wind energies have a growing role to play in the energy market as climate change ensues, there is a need for a reliable renewable source such as nuclear energy. Despite the continued development of solar and wind energies, the use of nuclear power has decreased in the past decades; many once operational plants turned offline and multiple plants in production shut down completely following the infamous incidents at Chernobyl, Three Mile Island, and Fukushima. More specifically, "the U.S. Nuclear Regulatory Commission cancelled pending requests to restart plant reactors and extend operating licenses based on new-found political controversies" (Koerner, 2014, p. 241). These unfortunate events led to some societal distrust in their governments and public support for the nuclear industry began to dissolve. Many could no longer envision a future where nuclear energy played a large role. Even decades after these events, many are uncertain about the safety of nuclear power.

While the concerns over safety are important components to consider, the chance of another major accident occurring in the United States is unlikely. “The risk of this happening at nuclear power plants in the United States is small because of the diverse and redundant barriers and safety systems in place at nuclear power plants, the training and skills of the reactor operators, testing and maintenance activities, and the regulatory requirements and oversight of the U.S. Nuclear Regulatory Commission” (EIA, 2020a). Despite the confidence that government bodies espouse in the power and potential of nuclear energy, increasing public support has been the primary obstacle deterring the continued use and development of this renewable technology.

The dominant concern is where to store the spent nuclear fuel. Clearly, radioactive waste should be disposed of carefully, away from large population centers. In 1987, Yucca Mountain in Nevada was proposed as a location, yet there has been much opposition from those in the state and the plan was ultimately thrown out in 2009 (Rott, 2019). More recently, a desert thirty-five miles away from the remote town of Carlsbad, New Mexico was suggested. Again, local concerns have prevented moving forward with the site. Many groups express concern over the safety of transporting such waste to the site and the repercussions it could have on the environment (Rott, 2019). However, it should be noted that, “thousands of shipments of commercially generated spent nuclear fuel have been made throughout the United States without causing any radiological releases to the environment or harm to the public” (U.S. Nuclear

Regulatory Commission, 2020). Still, the federal government has yet to find a viable storage area where the state has fully accepted the responsibility.

More specifically, locals and national groups alike are concerned about the possibility such radioactive particles may leak into American water ways and thus impact natural resources or even disperse into the air. With this proposed site, an additional obstacle to nuclear storage include fears from those in agriculture and ranching. Journalist Matt Rott (2019) mentioned how ranchers and dairy farmers were uncertain how their consumers would react with their production being in such close proximity to radioactive storage.

Whether these fears are justified or not, they play a role in how individuals and the collective understand nuclear energy. This fear, in part due to the three major nuclear incidents, and the storage issue has led to opposition to expanding nuclear energy usage. Despite the boost in the economy in the form of tax revenues, high-paying jobs, and stable incomes that come with accepting a private nuclear storage site and nuclear power plant, fear has overruled the economic benefits on the local and national scale. The public's resistance has led the federal government to continue its search for the right location where the residents support the measure. Due to the concern around nuclear waste, many are pushing back against continuing the development of new plants. Evidently, public perception has immense power to decide the future of nuclear policy.

Following the three major incidents, citizens no longer trusted their government to safely work with powerful tools such as nuclear energy. To combat such distrust and lack of cooperation with the government, the Obama administration selected a Blue Ribbon Commission to explore solutions to the nuclear waste storage problem. Ultimately, the panel suggested a "consent-based approach" to finding the right location to avoid another struggle like the one seen at Yucca Mountain (Rott, 2019). The Blue Ribbon Commission (2012) stated, “We believe this type of approach can provide the flexibility and sustain the public trust and confidence needed to see controversial facilities through to completion” (p. ix). With the dangers and risk that spent nuclear fuel bring, especially after the incident at Chernobyl, the federal government thought it would be more acceptable to have the local community accept the plan instead of forging ahead which would certainly lead to massive backlash.

While it has been difficult in America to find a location for the spent fuel, it is not impossible. A nuclear company in Finland provides an excellent example of working with the local people to find the best solution. The clear distinction between the conflict at Yucca Mountain and the accepted location on Olkiluoto Island in Finland is how the nuclear waste management company sought consent from the proposed communities. Instead of deciding and announcing where the Finnish repository would be, five locations were selected for additional research and offices were opened in each community to provide information (Fountain, 2017). Moreover, each community was consulted about the project and given veto power should that location be selected (Fountain, 2017). In addition to the company’s transparency about the project, the Finnish government ensured that the companies creating the waste were responsible for disposing of it too (Fountain, 2017). Unlike Finland, the United States national government takes on the responsibility of nuclear waste disposal, yet this makes it subject to political pressures (Fountain, 2017).

Although the American government has attempted to repair the integral relationship with the public by seeking out a state’s consent for the nuclear waste storage facility, costs are rising in the decades long search. Since the Department of Energy has not found a permanent location for the waste storage as promised to by 1998 in the Nuclear Waste Policy Act, $2 million dollars a day of taxpayer money goes towards paying utilities to store the nuclear waste on-site (Rott, 2019). Additionally, many of those nuclear power plants with on-site waste storage are located near coastlines or rivers, where flooding and natural disasters occur more often (Rott, 2019). Thus, research on possible locations away from human activity and negotiations with communities should begin as soon as possible.

When the tsunami hit Japan in 2011, which resulted in some nuclear radiation leakage, the information spread instantaneously through various channels all around the world. Unlike the nuclear incidents at Chernobyl and Three Mile Island, people saw and experienced the outcomes of such an incident in a much more personalized way due to the advances in technology and the evolution of social media. While there may be many advantages to news spreading quickly, particularly becoming more accessible, such technological advances should be used with caution. "'We live in the Internet age where people can be selective about what news they get…' said nuclear blogger Dan Yurman" (Friendman, 2011, p. 56). This selectivity means the population may be exposed to only one perspective on nuclear energy, with people most likely encountering negative views of it following the accident.

Similarly, Sharon M. Friendman (2011) states, "Many private individuals and groups with Internet and social-media connections presented their own 'news,' their interpretations of news from traditional media or their points of view on blogs, Facebook, Twitter, and YouTube," and if some source goes viral on the internet, it becomes widely distributed without any verification of the source's credibility (p. 56). This reality of social media usage poses large obstacles to gaining broad support for nuclear energy. Not only does receiving news mainly or solely from social media tend to lead to one-sided information on nuclear power, but it also skews the public perspective negatively.

In addition to unreliable sources floating around on social media, newspaper articles tend to portray nuclear power in an unfavorable light. In the study *Media, Fear, and Nuclear Energy: A Case Study*, Cassandra L. Koerner (2014) found an overwhelming percentage of newspaper headlines showing nuclear energy in a negative light. Over the three major incidents, more than 70 percent of headlines were negative, compared to positive or neutral. When considering the data collected on *The New York Times*, 72% of their headlines presented Three Mile Island negatively, 80% presented Chernobyl negatively, and 60% presented Fukushima negatively (Koerner, 2014, p. 244). See Appendix A for the data table.

Koerner (2014) notes in her discussion how media affects personal values and thus, decision making on an individual level (p. 245). The distribution of skewed media to much of the country has the ability to sway policy decisions and voting patterns (Koerner, 2014, p. 245). Public perception is inextricably tied to policy outcomes in this manner. James Stoutenborough, Shelbi Sturgess, and Arnold Velditz (2013) write in their paper *Knowledge, Risk and Policy Support: Public Perceptions of Nuclear Power*, "Without public support, there may be little motivation for policymakers to act on an issue like nuclear power regardless of the scientific support" (p. 176). Therefore, to change nuclear policy, one must understand the ways public perception is greatly influenced.

The media's negatively skewed headlines can be a result of various reasons. Tim Goodman, a chief television critic for *The Hollywood Reporter* suggested that such pessimistic headlines may have been done purposefully to increase ratings and attract more viewers (Friendman, 2011, p. 62). Similarly, Friendman (2011) stated "Particularly scientists and those with technical knowledge, criticized both the traditional and the social-media coverage, saying scare tactics once again rode the media waves and increased the public's nuclear phobia" (p. 62).

The for-profit nature of media and newspaper companies easily lends itself to manipulation of controversial topics such as nuclear power. Alvin M. Weinberg (1961) reiterated such sentiment in his article *Impact of Large-Scale Science on the United States*, “Issues of scientific or technical merit tend to get argued in the popular, not scientific, press… the spectacular rather than the perceptive becomes the scientific standard” (p. 161). Thus, it is essential to scrutinize media perspectives, especially regarding “click bait” headlines, and instead opt to receive information from more science-based outlets.

Not only were newspapers employing unfavorable language in their headlines, but the newspaper articles were also incomplete in their reporting of Chernobyl, Three Mile Island, and Fukushima. The majority of newspaper reporters knew little about the complexity that is nuclear power, much less were able to ask adequate questions about the damage of the incidents (Friendman, 2011, p. 57). The inability of the reporters to ask the right questions inhibited the public from correctly understanding the impact of the incident and what it meant for nuclear energy in the United States. Unfortunately, this effect was compounded by knowledgeable engineers who spoke in technical jargon that few journalists and everyday citizens understood (Friendman, 2011, p. 57).

In the reporting of Three Mile Island specifically, only 16 of the 234 radiation reports reviewed in Friendman’s study were complete. “To be complete, according to the Task Force’s strict standard, a radiation report had to include the amount; the unit, rate, time, and duration; where the reading was taken; the nature and type of radioactive material; and the type of exposure. While the amount and unit were almost always included in the articles, almost everything else was missing” (Friendman, 2011, p. 58). Without the rest of the context, the information that was provided in the radiation reports could easily be misunderstood and amplified for the reader, causing them to have negative associations with nuclear energy.

The Economics

For some, the high fixed capital costs of nuclear plants are an additional deterrent to their usage. Advanced nuclear plants cost approximately $6,041 per kilowatt, whereas ultra-supercritical coal plants without CO_2 capture are only $3,676 per kilowatt (EIA, 2020c, 11-4 and 1-5). However, the capital cost of nuclear is somewhat offset by its low variable operational and maintenance cost (O&M), which is $2.37 per megawatt hour (EIA, 2020c, 11-2). The O&M cost for coal is twice as much, at $4.50 per megawatt hour, compared to the O&M cost for nuclear (EIA, 2020c, 1-8). However, solar plants fare better in both cost respects with a capital cost of $1,313 per kilowatt and an O&M cost of $0.00 per megawatt hour (EIA, 2020c, 24-4).

However, there are possibilities for the capital cost of nuclear plants to decrease in the future. Recently, there has been an interest in creating small modular reactors (SMR) which produce 300 megawatts per module or less instead of the typical reactor that generates between 500 and more than 1,000 megawatts (Issacs-Thomas, 2020). A company called NuScale Power has designed a SMR that produces only 60 megawatts (Issacs-Thomas, 2020). These smaller reactors are much simpler than the traditional nuclear plant and are supposedly safer with their light-water technology that does not rely on other sources of power to cool the reactor core in case of a power outage (Issacs-Thomas, 2020). Moreover, these SMRs are manufactured at one site and then shipped to their destination which cuts the construction costs (Issacs-Thomas, 2020).

In addition to costs, it is important to include capacity factor when assessing various generation technologies. Capacity factor represents the actual production compared to potential generation. Nuclear plants have the highest capacity factor out of all sources. The most recent report on the EIA's website from August 2020 has nuclear energy generating at 95.5% of its potential generation (EIA, 2020d). Alternatively, the capacity factor for solar was only 29.5% and 28% for wind this past August (EIA, 2020d). The capacity factor for solar during the winter months is even less with values in the range of twelve to low twenties (EIA, 2020d). This means there is a need for another source of electricity that can be used on command if America tries to rely on renewables. If the goal is to reduce carbon emissions, instead of using expensive, carbon-producing peaker plants, batteries are an alternative. Yet historically, batteries have been extremely expensive. As one considers scaling up solar and wind generators to provide the majority of American electricity, the amount of battery storage needed also increases.

In terms of employment, the nuclear industry currently employs 70, 323 people with the sector decreasing by 2.5% last year (NASEO & EFI, 2020, p. xvii). Employment in the nuclear industry is considerably less than in other renewables. For example, solar employs 248,000 people with an increase in employment of 2.3% (NASEO & EFI, 2020, p. xii). Wind employs 114,800 with a 3.2% growth in employment (NASEO & EFI, 2020, p. xii). Such growth can partly be attributed to the decreasing prices of these renewables. Solar photovoltaic prices have decreased by 89% on average in the last decade with wind energy prices decreasing by 70% (Marcacci, 2020). It is unsurprising that the nuclear sector is not growing due to the continued pushback from the public. It would be reasonable to assume that if there was more public support for nuclear technology, the industry would grow as America continues to move away from coal.

While the nuclear industry does not provide as many jobs as solar nor wind, it does pay workers a higher wage. On average, the local salary of a nuclear worker is 30% higher compared to other jobs in the area (Office of Nuclear Energy, 2020). In 2019, the median salary of a nuclear technician was $82,080 per year (U.S. Bureau of Labor Statistics [BLS], 2020b). Alternatively, in 2010, the median salary of a technician in the solar industry only made $51,060 (Hamilton, 2011, p. 9). While a solar technician's salary has risen since 2010 due to inflation, it is likely still substantially less. This salary difference holds in other occupations within their respective industries. In 2019, nuclear power reactor operators had an average salary of $100,990 (U.S. BLS, 2020a). In 2010, solar power plant operators made a median salary of $64,270 (Hamilton, 2011, p. 16).

In addition to the economic benefits of providing employment, energy jobs contribute to the economy through multipliers at the local, state, and national level. For every one job directly created by a 1,000 megawatt power plant in the nuclear industry, 1.66 jobs, 2.36 jobs, and 8.26 jobs are created at the local, state, and national level respectively (Nuclear Energy Institute, 2012, p. 3). This may occur due to the increase in spending in other areas of the economy, perhaps at restaurants, event venues, and grocery stores thereby creating the need for such places to hire extra help. Likewise, for every one dollar of income a worker earns at a 1,000 megawatt power plant in the nuclear industry, $1.22 is earned by other workers in the local economy (Nuclear Energy Institute, 2012, p. 3). This effect grows as the scope of the economy expands with that one dollar of income acquired by the nuclear plant worker turning into $1.49 earned by other workers at the state level and $3.75 earned in the entire American economy (Nuclear Energy Institute, 2012, p. 3). See Appendix B for the data table. It is assumed that workers in other energy sectors contribute to the economy through multipliers as well.

The Risk

While nuclear energy has some risk involved in its operation, so too does coal and other sources of electricity generation. Yet, fossil fuels incidents are not portrayed as such a high level threat in the media like nuclear incidents are. When considering the historical data, nuclear power rarely injures or kills. Furthermore, engineers have found that fact remains even as they model thousands of scenarios for potential accidents (Brown, 2011). “Compared with nuclear power, coal is responsible for five times as many deaths from accidents, 470 times as many deaths due to air pollution among members of the public, and more than 1,000 times as many cases of serious illness” (Brown, 2011, para. 8). Despite these alarming rates, coal is still seen as a safer alternative to nuclear in the public mind and continues to produce almost a quarter of the electricity in America today (EIA, n.d.b).

If nuclear power did not exist, the electricity generation it has produced would have come from fossil fuels with coal being the primary replacement based on historical energy production (Kharecha & Hansen, 2013). The theoretical replacement of nuclear power to fossil fuels would have produced a large amount of greenhouse gas emissions which contributes to air pollution mortality (Kharecha & Hansen, 2013). Authors Kharecha & Hansen (2013) found that, “despite the three major nuclear accidents the world has experienced, nuclear power prevented an average of over 1.8 million net deaths worldwide between 1971-2009” (para. 4). Based on their study, an average of 76,000 deaths were avoided annually between 2000 and 2009 due to nuclear power (Kharecha & Hansen, 2013). See Appendix C. Mortality associated with emissions should be a critical factor when considering which sources to use for electricity generation. By allowing a more comprehensive review of coal generators, the costs and benefits of nuclear power may change in the favor of its use. Ultimately, as the data shows, the damage done by coal both directly and indirectly is not trivial and it may be time to reconsider the role of nuclear as climate change worsens.

In fact, a group of researchers found that the costs of turning nuclear offline in Germany were much higher than the benefits of such action. After the incident at Fukushima in 2011, anti-nuclear sentiment grew and ten of the 17 nuclear reactors shut down in the following months. The other seven reactors are planned to retire in 2022. However, the study concluded that the nuclear phase-out has led to increased production by coal and natural gas plants to fill in the electricity gap left by nuclear plants (Jarvis et al., 2019). This phenomenon has led to increased greenhouse gas emissions as well as deaths from air pollution. Specifically, CO_2 emissions amounted to 316.6 megatons on average per year with the phase-out whereas they would have only been 280.8 megatons per year in a counterfactual scenario without the phase-out (Jarvis et al., 2019, p. 46). If the nuclear reactors continued to produce society would have seen a 13% decrease in CO_2 emissions relative to the reality with the phase-out (Jarvis et al., 2019, p. 46). See Appendix D. With the valuation of coal at $50 per ton of CO_2, the nuclear phase-out led to $1.8 billion in climate damages (Jarvis et al., 2019, p. 25).

Additionally, mortality, measured as excess deaths per year, totaled 8,549.7 on average while a the counterfactual scenario would have led to 7,407.2 deaths, or a 15.4% reduction in mortality relative to the reality with the phase-out (Jarvis et al., 2019, p. 46). See Appendix D. Each year between 2010 and 2017, local emissions (including SO_2, NO_x, and PM) from fossil fuel plants amounted to $65 billion in mortality costs with $8.7 billion attributed to the nuclear phase-out (Jarvis et al., 2019, p. 25). This represents a 15% increase in damages relative to the counterfactual scenario (Jarvis et al., 2019, p. 25). Alternatively, this can be seen as an additional

1,100 deaths per year due to the increase in these local pollutants, which mainly from hard coal plants (Jarvis et al., 2019, p. 25).

Mark Szybist, a senior attorney with the Natural Resources Defense Council in the United States, stated, “We’re at a point where if nuclear retires immediately, we would probably replace it with natural gas generation because we haven’t sufficiently planned to replace it with something cleaner” (Cusick, 2019, para. 19). Evidently, decommissioning nuclear plants based on fear and high capital costs leads to a reduction in carbon-free electricity in favor of fossil fuels. Given the extensive damage fossil fuels do to the environment and human life, it is important to reevaluate the role of nuclear. If the price of carbon is added into the economic analysis, nuclear energy becomes more competitive with natural gas and renewables.

Following the incident at Fukushima, almost the entire nuclear fleet was decommissioned in Japan as fear spread. In order for supply to continue to meet demand in the electricity market, the use of fossil fuels increased dramatically after 2011. Specifically, generation from coal and natural gas increased from 61% in 2010 to 87% in 2013 (EIA, 2015). The increased reliance on imported fossil fuels made electricity prices rise across the country. This price increase varied depending on how much the region used to rely on nuclear power; regions that did not use any nuclear saw a 10% increase in electricity prices while other areas that relied heavily on nuclear saw a 40% increase (Neidell et al., 2019, p. 3).

This price increase not only burdened people financially, but resulted in additional deaths. This occurred since people were no longer able to pay for the same amount of electricity, thus electricity consumption decreased particularly during the coldest times of the year (Neidell et al., 2019, p. 21). Given that electricity can help provide safety and health benefits during times of extreme weather, this reduction in electricity consumption led to an increase in mortality during these very cold temperatures (Neidell et al., 2019, p. 21).

Ultimately, the researchers found that the price increase resulted in at least 1,280 additional deaths during 2011 and 2014 (Neidell et al., 2019, p. 4). Since the study only considered the 21 largest cities in Japan, accounting for 28% of the total population, it is expected that deaths from the increased price are even greater for the entire nation (Neidell et al., 2019, p. 4). The study estimates imply over 4,500 deaths between 2011-2014 (Neidell et al., 2019, p. 21). Comparatively, there have been zero deaths directly tied to the Fukushima incident so far but projections estimate approximately 130 deaths will be attributed to the incident over time (Neidell et al., 2019, p. 21). Since the amount of deaths attributed to the increase in electricity prices is much larger than the deaths tied to the nuclear incident, it raises questions about whether turning off nuclear plants was truly beneficial. These findings highlight the need to analyze the outcomes of an action before making policy decisions. While nuclear is not risk-free, the alternative option may be far worse.

Policy Perception & Demographics

American society tends to view nuclear power negatively. Studies have shown there are clear differences in those who support nuclear power and those who are weary of it. Stoutenborough et al. (2013) explained, “While attitudes and values provide strong predictors of policy support, it is generally accepted that demographic characteristics also play an important role in public policy choices” (p. 177). For this reason, it is important to better understand the demographics of those in favor and those against nuclear energy in order to build broad support for nuclear policy. Data from the Pew Research Center shows that 53% of men favored the increased use of nuclear power and 42% of men opposed the idea whereas only 25% of women favored and 63% opposed it (2011). It is clear there is a wide gender gap between those who support nuclear energy and those who do not.

Another interesting pattern seen in the Pew Research Center data examined the role of educational attainment on opinion of nuclear power. For the research conducted in October of 2010, 37% of those with high school education or less favored promoting the increased use of nuclear power (Pew Research Center, 2011). For those with some college education, the percentage of those in favor increases to 45% and rises to 57% of those with a college degree (Pew Research Center, 2011). However, it must be noted that this pattern is not present when the Pew Research Center collected data in March of 2011 after the incident at Fukushima. See Appendix E for data table.

Assessment & Future Research

What was and still is needed are technical writers who understand complex issues such as nuclear power but are able to explain it in an accessible manner. Due to the rise of internet-based information sources, many newspapers have laid off writers, especially specialty writers in the science, environmental, and health fields (Friendman, 2011, p. 63). “To properly cover science, technology, and health issues, particularly on the scale of the Japanese nuclear disaster, the knowledge and experience of specialty reporters is greatly needed” (Friedman, 2011, p. 63). The lack of such knowledgeable reporters undoubtedly passed on confusion to the readers who were already frightened by the events. To avoid misinterpreting information, especially information that concerns the public’s safety and wellbeing, it is essential to employ those who can understand and explain nuclear power and its risk.

Such confusion on behalf of reporters and readers alike can have detrimental effects on individual decision making and policy outcomes. “From a policymaking perspective, individuals are more likely to make a mistake and choose improper solutions to problems when they operate with imperfect information” (Stoutenborough et al, 2013, p. 177). Thus, the lack of comprehensive and accessible information does make impressionable impacts on policy creation. In fact, Stoutenborough argues that the public will be unable to choose the best answers to policy issues, thereby negatively impacting policy creation, if they are not fully and accurately informed.

This lack of knowledge of nuclear power contributes to a knowledge gap, which is further emphasized by the difference in opinion between scientists and the layperson. Generally, scientists support the use of nuclear energy and believe it is a, “safe alternative to fossil fuel-based energy production so long as nuclear power plants are properly constructed and regulated” (Stoutenborough et al, 2013, p. 178). The Pew Research Center (2015) found that 65% of all scientists within the American Association for the Advancement of Science (AAAS) support building more nuclear plants, including those working as Ph.D. scientists and active research scientists. Out of all AAAS members, only 33% opposed building more nuclear plants (Pew Research Center, 2015). By contrast, only 45% of U.S. adults favor building more nuclear plants while 51% oppose the action (Pew Research Center, 2015). Moreover, when the AAAS members were categorized by discipline, 79% of all physicists and working Ph.D. physicists, 75% of all engineers, and 66% of Earth scientists favored building more nuclear plants (Pew Research Center, 2015). Ultimately, regardless of discipline, scientists support nuclear power at a much higher rate than the general U.S. adult population. This conclusion suggests as one increases their knowledge of nuclear, one is more likely to be in favor of expanding nuclear power.

While decision makers believe it is important to consult experts, policy makers will tend to promote the views of their constituents (Stoutenborough & Vedlitz, 2012). Ultimately under our democratic government, nuclear policy is more heavily informed by the public rather than the experts and scientists. This occurrence reinforces the need to adequately educate the public around the advantages, the risk, and the reality of nuclear power.

When looking at the knowledge gap, it is essential to examine the gender gap as well. As previously mentioned, men are generally more supportive of nuclear energy usage, whereas women are in opposition. In order to build broad support for nuclear energy policies, one must understand where the opposition lies and the reasoning behind the aversion. There are various hypotheses to explain the gender gap. Considering that most scientists support the use of nuclear energy, given precautionary measures and regulation, it is necessary to analyze the impact of the gender gap in science, technology, engineering, and math (STEM) fields. Women are vastly underrepresented in the STEM field with only 28% of the workforce being female (AAUW). Additionally, women are incredibly outnumbered by their male peers in STEM classes in college (AAUW).

In hopes to understand the lack of female support for nuclear power, it is pertinent to continue researching these gender gaps in the future. Specifically, concerning the correlation between the two gender gaps; will the gender gap in opinion of nuclear energy narrow as the gender gap in STEM narrows? This research would occur as a longitudinal study since it may take time for information in college classes and experience in the STEM field to influence personal opinion of nuclear energy. If the gender gap in STEM narrows, yet the gender gap in nuclear power remains, it will be important to continue studying other facets that affect personal opinion and decision making such as the sources that the public receives their information from and risk aversion between men and women.

Furthermore, to better understand the knowledge gap one might apply the Knowledge Deficit Model (KDM) to nuclear policy. This model assumes, "that expert and public attitudinal congruence is more likely if the knowledge gap between the two groups shrink" (Stoutenborough et al, 2013, p. 178). To apply this model, one would measure the level of understanding and level of support for various policy options concerning nuclear power among different groups of everyday citizens. After this initial assessment, the participants would attend some sort of educational course or informative training on nuclear power. Following this, there would be a reassessment of the participants using the same method as before to measure their understanding and support of policy options. If the KDM is accurate, "we should expect to see that the public and experts will begin to coalesce around similar policy options as the public becomes better informed" (Stoutenborough et al, 2013, p. 178). In doing this research, one could determine whether providing further information on nuclear power, thereby narrowing the knowledge gap, alters the layperson's opinion on nuclear power and if in fact, the public's choice of policy becomes more similar to that of experts.

Lastly, it is important to acknowledge the technological advances that have already occurred within the industry despite major obstacles in public, and thus financial, support. These scientists have taken public concerns into consideration and are determined to find a solution that supports our environment. For example, TerraPower (n.d.), a nuclear innovation company founded by Bill Gates, is creating a Traveling Wave Reactor and is currently researching how to use molten salt reactor designs. Recently, researchers at Massachusetts Institute of Technology have teamed up with Commonwealth Fusion Systems to study nuclear fusion (Fountain, 2020).

Their new design called SPARC would rely on hydrogen for fusion instead of uranium, which would be less radioactive and would produce less waste than traditional plants (Fountain, 2020). There is also the Idaho National Laboratory who is building small advanced nuclear reactors which are powered by spent fuel (Oberhaus, 2020). While nuclear power has challenges, innovation in the field is not dead. Rather, ideas are out there and companies are already redesigning and re-envisioning what nuclear power can look like, but America would need to commit to furthering the possibilities and investing in zero-carbon solutions.

Conclusion

Between the rising sea levels, ocean acidification, and warming temperatures the impacts of climate change have been devasting. In order to slow down these damaging repercussions, America must reduce greenhouse gasses. Carbon dioxide is a major contributor to global warming and the energy market plays a major role in producing such emissions, mainly coming from coal-fired power plants. While solar and wind power have been promoted as a valuable source of renewable energy, there are a multitude of issues with scaling up those sources as of now. Alternatively, nuclear energy has the ability to reduce carbon emissions and act as a reliable baseload plant to consistently provide electricity, yet there is immense political resistance to its usage.

From my research, it seems that nuclear energy has been misunderstood by the public. While there is risk associated with nuclear energy, one must also take into account the benefits of a greener future. Evidently, turning off nuclear plants only increases carbon emissions through the expansion of fossil fuels. However, the opposition to nuclear remains. For nuclear policy to succeed there must be broad support, which means the public must be accurately informed.

Therefore, it is essential to employ technical writers who fully understand nuclear technology and are able to assess its risk. Additionally, the public should be educated on the biases for-profit companies may have that could alter the information they receive.

Another facet of building broad support means examining the gender gap and the reasons behind the lack of female support. In the future, one could apply the Knowledge Deficit Model to better understand the gender gap as well as further learn about societal perceptions of nuclear energy and the possibilities of overcoming it. It is true there is risk associated with the use of nuclear power, but the costs of using fossil fuels is higher. Nuclear power has the unprecedented ability to move us closer to a cleaner world, by lowering CO_2 emissions and it may be time to reconsider its potential today.

Appendix A

Table 3
Percent of headlines in positive, negative, and neutral classifications.

	Positive	Negative	Neutral
Three Mile Island			
The Globe and the Mail (Canada)	12.50	75.00	12.50
New York Times (U.S.)	22.64	71.70	5.66
Chernobyl			
The Globe and the Mail (Canada)	22.67	79.76	4.00
New York Times (U.S.)	10.71	79.76	9.52
Fukushima			
The Globe and the Mail (Canada)	37.84	62.16	0
New York Times (U.S.)	18.52	59.26	22.22

(Koerner, 2014, p. 244)

Appendix B

Impact of a 1,000 MW nuclear plant on Local, State and National Economies

Units	Region	Effect	Output	Labor Income	Employment
Multipliers		Direct	1.00	1.00	1.00
	Local	Direct + Indirect/Induced	1.04	1.22	1.66
	State	Direct + Indirect/Induced	1.18	1.49	2.36
	National	Direct + Indirect/Induced	1.87	3.75	8.26
			$ 2010 Millions		
Dollar and job values per gigawatt	Local	Direct	453	36	319
		Direct + Indirect/Induced	471	44	528
	State	Direct	453	61	505
		Direct + Indirect/Induced	533	91	1,192
	National	Direct	453	65[7]	530
		Direct + Indirect/Induced	846	244	4,372

Source of data: IMPLAN model. See detailed description on pages 5-6.

(Nuclear Energy Institute, 2012, p. 3)

Appendix C

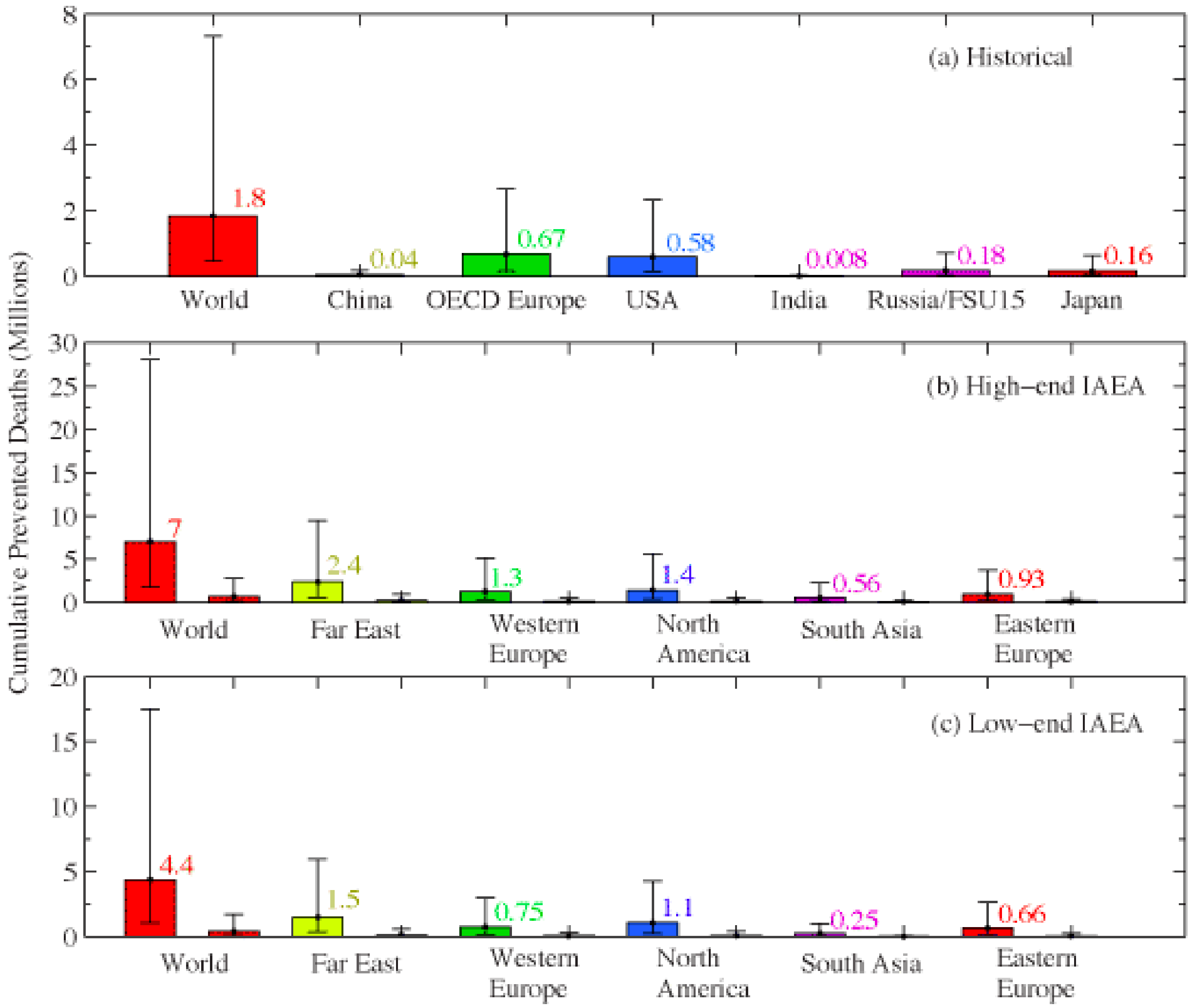

Figure 1. Cumulative net deaths prevented assuming nuclear power replaces fossil fuels. The top panel (a) shows results for the historical period in our study (1971-2009), with mean values (labeled) and ranges for the baseline historical scenario. The middle (b) and bottom (c) panels show results for the high-end and low-end projections, respectively, of nuclear power supply estimated by the IAEA (ref. 4) for the period 2010-2050. Error bars reflect the ranges for the fossil fuel mortality factors listed in Table 1 of our paper. The larger columns in panels (b) and (c) reflect the all-coal case and are labeled with their mean values, while the smaller columns reflect the all-gas case; values for the latter are not shown because they are all simply a factor of about 10 lower (reflecting the order-of-magnitude difference between the mortality factors for coal and gas). Countries/regions are arranged in descending order of CO_2 emissions in recent years. FSU15=15 countries of the Former Soviet Union and OECD=Organization for Economic Cooperation and Development.

(Kharecha & Hansen, 2013)

Appendix D

Table 5 Estimated Impact of the Nuclear Phase-Out on CO_2 Emissions and Local Air Pollution Mortality Damages

	Average with Phase-Out (1)	Average w/out Phase-Out (2)	Change (3)	Change (%) (4)
CO_2 Emissions (Mt/Year)	316.6	280.3	36.3	13.0%
Lignite	182.8	175.9	6.9	3.9%
Hard Coal	108.0	82.2	25.8	31.4%
Gas	17.0	13.6	3.3	24.5%
Oil	8.9	8.6	0.3	3.6%
SO_2 Emissions (Kt/Year)	151.7	135.8	15.9	11.7%
Lignite	94.7	91.4	3.2	3.5%
Hard Coal	49.5	37.2	12.3	33.0%
Gas	1.2	1.0	0.2	18.4%
Oil	6.3	6.2	0.2	2.5%
NO_x Emissions (Kt/Year)	213.4	189.7	23.7	12.5%
Lignite	121.5	116.8	4.7	4.0%
Hard Coal	69.0	52.5	16.5	31.5%
Gas	12.1	10.0	2.2	21.8%
Oil	10.7	10.4	0.3	2.9%
PM Emissions (Kt/Year)	5.5	4.9	0.6	12.2%
Lignite	3.3	3.2	0.1	3.9%
Hard Coal	2.0	1.5	0.5	30.3%
Gas	0.1	0.1	0.0	24.6%
Oil	0.2	0.1	0.0	3.3%
Mortality (Excess Deaths/Year)	8,549.7	7,407.2	1,142.4	15.4%
Lignite	4,142.9	3,988.1	154.9	3.9%
Hard Coal	3,776.2	2,870.9	905.3	31.5%
Gas	366.1	293.0	73.1	25.0%
Oil	264.4	255.3	9.2	3.6%
Pollution Damages ($bn/Year)	65.3	56.6	8.7	15.4%
Lignite	31.6	30.5	1.2	3.9%
Hard Coal	28.8	21.9	6.9	31.5%
Gas	2.8	2.2	0.6	25.0%
Oil	2.0	1.9	0.1	3.6%

Notes: This table reports estimates for emissions of CO_2 as well as three local pollutants: SO_2, NO_x, and PM. The final row presents estimates of the mortality damages from all three of these local air pollutants. All values are annualized averages based on predictions from immediately after the March 2011 to the end of 2017. Emissions are the product of each plant's hourly generation with our estimate of their emissions rate. Emissions rates are the product of (a) the amount of fuel required to produce one unit of electricity, and (b) the emissions intensity of the fuel. Emissions estimates are limited to fossil-fuel-fired plants in Germany. We ignore other potential sources of emissions in the electricity sector, such as emissions from smaller biomass, landfill gas or waste plants. We also focus on emissions and damages in Germany and so do not estimate changes in emissions in neighboring countries due to changes in net imports. For the pollution damages reported in the last row of the table, we present only the monetary costs associated with premature mortality due to air pollution exposure in order to ensure consistency with the complementary analysis using pollution monitor data.

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(Jarvis et al., 2019, p. 46)

Appendix E

Fewer College Graduates Back Increased Use of Nuclear Power

Promoting the increased use of nuclear power...	Oct 2010		Mar 2011	
	Favor	Oppose	Favor	Oppose
	%	%	%	%
Total	45	44	39	52
Men	58	36	53	42
Women	33	52	26	63
18-29	39	51	41	55
30-49	43	49	34	60
50-64	49	40	42	49
65+	49	34	45	42
College grad+	57	35	44	50
Some college	45	45	37	54
HS or less	37	50	38	53
Republican	57	35	49	41
Democrat	36	55	31	60
Independent	47	42	41	54

PEW RESEARCH CENTER Mar. 17-20, 2011. PEW27b. Figures may add to 100% because of rounding.

(Pew Research Center, 2011)

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