RADIOACTIVE REVERSAL?

THE FUKUSHIMA ACCIDENT AS A FOCUSING EVENT FOR COMPARATIVE POLICY CHANGE ON NUCLEAR ENERGY

by

Victoria Justine Sanchez

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Political Science and International Relations.

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ABSTRACT

This dissertation project examines the 2011 Fukushima nuclear accident as a focusing event for policy change on nuclear energy. For example, following the accident, Germany (and much of Europe) experienced a reversal of policy on nuclear energy. Conversely, many others such as China, Russia, and France, did not exhibit such a retraction against nuclear power, albeit with public debate about the risks and consequences of accidents. Why has there been dramatic policy change in some cases but not others? The political and literal fallout of Fukushima has provoked a wave of policy change towards nuclear energy at the national level. Through qualitative and quantitative measures, we can view Fukushima as an impetus for comparing the dynamics of nuclear policy change. Quantitatively, this project employs logistic regression to explore variables such as regime type, energy security, trade supply and demand, climate change concerns, and public acceptance are related to policy outcomes and change on nuclear energy in the post-Fukushima context of 49 different countries. Qualitatively, country cases (Russia, Germany, and Canada) are assessed into three categories based on the outcome of policy decisions on nuclear energy following Fukushima for a richer analysis. Beyond the Fukushima example, we can hope to better understand how political focusing events can gain influence in an international context.

Chapter 1

INTRODUCTION

There was a little girl,
Who had a little curl,
Right in the middle of her forehead.
When she was good,
She was very good indeed,
But when she was bad she was horrid.
- Henry Wadsworth Longfellow
"There Was a Little Girl"

Nuclear energy has been divisive since its inception. For its advocates, it is a sustainable means of electricity generation that does not emit greenhouse gas emissions and offers the potential to reduce foreign energy dependence. For those in opposition, the potential for negative consequences from nuclear energy production outweigh any benefits. In particular, opponents point to concerns about environmental contamination and waste control.[1] Furthermore, when nuclear accidents happen, they underscore the complicated and expensive challenges associated with risk-oriented

[1] For an overview of some of these concerns, see: Stone (2016); Alario and Freudenburg (2003); Cohen and McKillop (2012); Kahn (2007); Kuo (2014); and Slovic, Flynn, and Layman. (1991). Environmental and waste management concern over spent nuclear fuel are one of the primary unresolved problems with nuclear energy that opponents significantly use to advance their cause. For example, in the United States, antinuclear opponents have successfully promoted legislation passed in some states that forbids the construction of nuclear power plants until there is a permanent disposal option for spent fuel, effectively limiting options for nuclear energy. Furthermore, "nightmare scenarios" about spent nuclear fuel (see Stone 2016) continue to haunt even advocates who call nuclear energy a clean energy source.

approaches to nuclear energy. Trust in nuclear energy is not a pressing or present concern, except when something goes wrong. In this respect, the Henry Wadsworth Longfellow poem about "the little girl with a curl" rings true about nuclear energy: when it is good, all is fine, but when it is bad, a horrific downside is revealed. Nuclear energy offers the potential for efficient and zero carbon emitting energy generation. But with these benefits comes the potential for reactor meltdowns, radiation leakages, contamination, and disaster. Indeed, these consequences are familiar to any who recall Chernobyl or Fukushima.

The 2011 Fukushima accident was a defining event for nuclear power, both in terms of the regulation and safety of ongoing nuclear operations and in terms of the prospective potential for nuclear generation in the future. And yet, in the years that followed, it remains unclear whether the accident positively or negatively influenced the future potential for nuclear energy development. Prior to Fukushima, nuclear energy appeared to be in a renaissance. Its advocates hoped, at last, nuclear power would provide a carbon-free and reliable base-load generation future. The Fukushima accident suddenly alerted the world to the danger and extensive consequences that can come from nuclear energy production. In a sense, many heralded Fukushima as the death knell for global nuclear energy futures. Immediately after the accident, some countries abandoned or reversed their nuclear energy programs. However, other countries remained committed to nuclear power and curiously, some made additional plans to expand nuclear energy, in spite of the negative shadow cast by Fukushima. The diversity of reactions to Fukushima raise fundamental questions as to how nuclear accidents impact the prospects for nuclear energy in a country. Following the

Fukushima accident, how did some countries effectively pull away from nuclear energy, while others decided to advance their civil nuclear capacity?

How and why does this happen? This dissertation project is interested in the degree to which nuclear accidents change the narrative of and future potential of nuclear energy. Particularly, how did the most recent Fukushima accident impact the global future of nuclear energy? Why, following the accident, did some countries adopt a more anti-nuclear stance while others adopted a more pro-nuclear stance? The course of events from the Fukushima accident has served as a potential impetus for policy change on nuclear energy. This project is interested in unraveling the factors that have predisposed policy change outcomes on nuclear energy in the aftermath of the Fukushima accident. Following some background information, the argument of this dissertation project will be detailed bellowed and expanded over the subsequent chapters.

1.1 Background on the Fukushima Accident

Prior to the disaster at Fukushima, the establishment and maintenance of nuclear energy had been a strategic priority for Japan. As a country of mountainous island chains with no reserve fossil fuel resources, Japan has to import 83 percent of its energy needs (as of 2017). Following its rapid industrialization after World War II, Japan initially relied heavily upon unstable oil imports, but following the global petroleum shocks of the 1970s, the government prioritized the development of a civil nuclear energy program that could provide the country with a stable domestic source of energy production. Following the 1970s, Japan brought over fifty nuclear reactors online. These reactors accounted for almost thirty percent of all energy generation.

Prior to Fukushima, Japan planned to increase its nuclear energy generation to at least forty percent by 2017. In 2011, many considered Japan’s nuclear energy program to be one of the most technologically sophisticated and safest in the world. However, the events of March 11, 2011 led to serious reconsideration of nuclear power in not only Japan, but also around the world.

A 9.1 magnitude underwater earthquake struck 43 miles of the east coast of Japan near Tohoku on March 11, 2011. It is the most powerful earthquake to have ever hit Japan and, since recording began in 1900, the fourth most powerful to strike. The earthquake triggered a powerful tsunami that reached heights of 133 feet and traveled up to six miles inland. The devastation from the natural disaster was extensive. In all, figures from the national police force put the death toll at 19,000 people. The World Bank estimated that the economic cost of the earthquake and tsunami was over $235 billion dollars, making it the most costly natural disaster in human history. In the aftermath of the calamity, Japanese Prime Minister Naoto Kan said, “In the 65 years after the end of World War II, this is the toughest and the most difficult crisis for Japan.” Following the earthquake of rare power, the earth’s axis is estimated to have shifted by up to 25 cm and portions of northeastern Japan were moved up to 7 feet closer to North America. Unfortunately, the toll and extent of the devastation was not limited just to the natural destruction from the earthquake and resulting tsunami.

The combination of the earthquake and resulting tsunami caused a technological disaster unlike any the world had ever seen at the Fukushima Daiichi nuclear power station. The Fukushima Daiichi nuclear power station comprised six boiling water reactors made by General Electric (GE) and managed by Tokyo Electric Power Company (TEPCO). The site is located on the Pacific Ocean and relied on its nearby source of seawater for cooling. At the time of the earthquake, units 4, 5, and 6 were shut down for refueling. However, at the time, their spent fuel pools still required cooling. Following the earthquake, several nuclear power plants in Japan initiated automatic “SCRAM” shutdowns of their nuclear reactors, including the Fukushima Daiichi units 1 through 3. Following these shutdowns, the plants lost the electric power used to pump cooling water on the reactors, prompting secondary backup diesel generators to be used for cooling systems. Initially, the nuclear power station’s backup procedures worked mitigated any potential effects of the earthquake.

However, 50 minutes after the earthquake the tsunami struck the Fukushima site and knocked out the backup diesel cooling units. The Fukushima site had a protective tsunami wall shielding the grounds that was built 10 meters high; unfortunately, the largest wave from the impending tsunami was 13 meters high and easily overcame the barrier. Following the tsunami, the diesel pumps were unable to sustain cooling and tertiary backup electric batteries were used to provide cooling for the enormous heat decay from the shutdown reactors. However, the batteries ran out after a day of use. Without the backup batteries, all three reactors at the Fukushima Daiichi site experienced core meltdowns, hydrogen air chemical explosions, and the release of radioactive material. Although there have been no linked fatalities to the nuclear accident, over 150,000 people were evacuated from the surrounding areas over concern for radiation contamination. TEPCO has since admitted fault for failing to meet basic safety requirements, such as, conducting appropriate risk assessments, preparing for containing collateral damage, and developing evacuation plans. It had prepared the nuclear plant for both earthquake and tsunami damage, but not both events occurring together.

The Fukushima accident caused significant reaction in Japan and around the world. Japan almost immediately halted of all of its nuclear power generation and compensated the loss of energy with costly foreign energy imports (largely in the form of liquefied natural gas). Japan faces an uncertain energy future. While some nuclear power reactors restarted recently, their future remains tenuous and highly contested by the Japanese public. Public opposition is largely against resuming nuclear power in the country, and even if existing power plants come back online, it remains highly dubious that any new reactors would get licensed. The nuclear future of Japan is thus largely still undecided. The Fukushima accident is counted as a level seven event (the most severe category) on the International Nuclear Event Scale by the IAEA. The only other event to have reached a level seven is Chernobyl. Plans for decontamination and cleanup are not yet final, but TEPCO estimates it will take 30-40 years to decommission the site. Estimates from December 2016 put the yearly costs for cleanup, decontamination, and compensation at $187 billion per year.

1.2 Global Reaction to Fukushima.

Since the rest of the world watched Japan grapple with the consequences of the Fukushima accident, national governments did not react uniformly. However, in the immediate aftermath, the immediate reaction from the public was mass-opposition. As Table 1 below indicates, within months of the Fukushima accident, the number of those opposed to nuclear power rose dramatically as compared to before the accident. All of the countries shown in the table experienced double-digit shifts in public opinion about nuclear power after the accident.

Table 1.1: Opposition to Nuclear Power Post-Fukushima

Increased opposition to nuclear after Fukushima (%)			
	Opposed before	**Opposed after**	**Change**
Germany	67	79	+12
Turkey	52	71	+19
Brazil	55	69	+14
France	53	67	+15
Russia	52	62	+10
Japan	28	58	+30
China	28	58	+30
UK	41	51	+10
US	36	48	+10
India	19	39	+20
Source: Ipsos (2011)			

Based on public opposition to nuclear energy following the Fukushima disaster, we would expect to see a wave of policy decisions that reflect the preferences of the public in the aftermath. Indeed, as would conform to expectations, some countries reversed their stance on nuclear energy after the accident. For example, the countries listed below shifted policy following unpopular public movements:

- **Switzerland**: The federal government decided within months after Fukushima to phase out nuclear power effectively by 2034, even though previously it had been focused on expansion. Presently, nuclear power accounts for approximate 35% of electricity in Switzerland.

- **Italy**: Following Chernobyl in 1987, Italy passed a referendum to close its four old existing nuclear reactors, but by 2011 the government was encouraging legislation to build new reactors. However, following Fukushima by June 2011, 94% of voters in a referendum rejected any new nuclear projects.[2]
- **Belgium**: Conditional plans to phase out nuclear energy by 2025 were under reevaluation prior to 2011; after the Fukushima accident the plans were ratified and the country pulled back from nuclear power.
- **Germany**: A year prior to the Fukushima disaster, the government had overturned a decision to phase out nuclear. An immediate federal election followed the Fukushima disaster and heavily politicized nuclear power. During this time, Germany decided to initiative a complete and rapid shutdown of all nuclear energy by 2022.
- **The Philippines**: A nuclear plant had long been under construction in the Philippines, but following Fukushima public concerns arose that this plant was also located along a volcanic fault line. After that, the government scuttled all plans to revive the plant and nuclear energy.

However, in other places around the world nuclear energy did not face such a dismal fate. In spite of public outcry, some countries continued to move forward with nuclear energy planning:

- **Spain**: The Socialist central government in place prior to Fukushima decided to phase out nuclear power through a moratorium, and several nuclear power

[2] According to Zaleski (2013) "Italy seems to have a special capacity for organizing referenda just after major nuclear accidents." (264)

plants under construction were abandoned. A new conservative Spanish government repealed the moratorium in December 2011.

- **Finland**: Despite public opposition following Fukushima, the country currently has one new reactor under construction and anticipates a second will begin construction in 2018. Finland seems on target to push forward with its plans for expansion, despite financial problems and delays at its nuclear power sites.
- **China**: Safety authorities declared after an initial post-Fukushima review that all operational reactors in China were safe. Since the accident, construction of new nuclear power plants has continued and plans for new nuclear plants have expanded since the Fukushima accident. After the accident, in December 2011 the Chinese National Energy Administration said that China would make nuclear energy the foundation of its power-generation system in the next "10 to 20 years." As of February 2017, Mainland China has 36 nuclear power reactors in operation, 21 under construction, and more about to start construction.
- **South Korea**: South Korea hosted a series of events to educate and raise awareness about nuclear energy in the nine months following the accident. It has become a major world exporter of nuclear technologies and made plans to hike its existing nuclear power generation capacity by 70 percent.
- **Poland**: Currently plans to forge ahead with its first operational plant. Fukushima did not impact scheduling or plans.[3]

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[3] Individual country source information from Zaleski (2013), Eliot (2012), Basrur et al. (2012).

The Fukushima accident has presents a paradoxical outcome: some countries seized on the immediacy of antinuclear sentiment after the accident, while continued to plough ahead with nuclear technology. According to Zaleski (2013), “plans to build nuclear power plants in new countries will be more difficult to implement after Fukushima and that people will be less enthusiastic. Therefore, at least some delays in initial nuclear plant construction plans are to be expected, and likely some countries (Thailand, Venezuela, Israel) will not develop nuclear energy in the foreseeable future.” (264) Even with all of the publicity of the accident, the reconsideration that a major accident brings to nuclear energy has not been enough to hamper the prospects for nuclear energy in some cases.

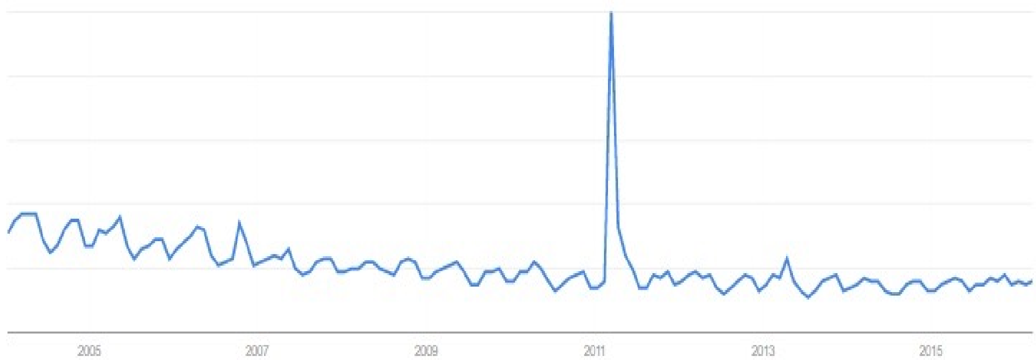
1.3 Why Care About Nuclear Accidents?

The premise of this dissertation is that a nuclear accident functions as a “focusing event” for future nuclear energy policy. Focusing events are an element of the agenda-setting process, in which some issues gain and others lose attention among policy makers and the public. Focusing events are defined as “sudden, relatively rare, can be reasonably defined as harmful or revealing the possibility of potentially greater future harms, inflicts harms or suggests potential harms that are or could be concentrated on a definable geographical area or community of interest, and that is known to policy makers and the public virtually simultaneously” (Birkland 1997, 22). As ideas increase or lose traction, a focusing event can reset the agenda and provoke a reassessment of a particular course of action.

When a nuclear accident happens, it can raise public awareness of nuclear power generation from latent acceptance to reevaluation. Without any accidents or incidents to raise the profile of nuclear power, its presence stays largely on the back burner of public consciousness. In this sense, nuclear power generally receives little awareness or notice by the public or policymakers at large (outside of dedicated policy spheres or advocacy related to nuclear issues) of concerns on the nuclear arena, and as a result policy decisions can linger on while nuclear is “out of sight, out of mind.” But when a major nuclear accident happens, suddenly it rises to a new level of public and political consciousness. As defined by Birkland (1998, 2006) a focusing event initially causes high levels of public attention. Especially in the modern age of twenty-four hour news and internet coverage, consumers are quickly alerted and information about the accident can travel far and quickly. A nuclear accident brings a spike in the interest of nuclear issues, and thus provides a focusing event for nuclear power policy.

In order to ascertain whether the Fukushima disaster actually renewed attention given to nuclear power, it is critical to carefully review a different types of public awareness data. Rather than using media attention given to the issue, it is best to consider sources directly from public input. As a stand in for this measure of public awareness, Google Trends tracking reveals public interest in nuclear issues measured before and after Fukushima. Figure 1 below illustrates how public attention to nuclear energy across the world changed over time measured as the frequency of Google searches for the term “nuclear.” The data are scaled to the average search traffic for the term “nuclear”. This data, taken from Google Trends tracks internet searches for the term “nuclear” starting in 2004 until 2016. The numbers shown on the graph are scaled to show total searches for a term relative to the total number of searches done on Google over time. A line trending downward means that a search term's relative popularity is decreasing. But, that does not necessarily mean the total number of searches for that term is decreasing. It just means its popularity decreased relatively compared to other searches.

Figure 1.1: Internet searches for “nuclear”[4][5]



Measuring public searches for information about a particular issue serves as a good metric for the public’s actual salience or attention to an issue. Rather than reviewing how the media described a particular issue, internet searches directly capture the interests and activities of citizens. As can be seen from the figure above, the relative prominence of nuclear energy search was mostly consistent or even slightly on the decline before the Fukushima disaster in 2011. Following the disaster, public searches spike, before it dropping off over the course of the year. These searches reveal a dramatic rise in the public attention to nuclear energy around the

[4] Measured by “Google Trends” (www.google.com/trends) from 2004 to present.

[5] While the search term “nuclear” also would capture accounts related to nuclear weapons, in addition to nuclear energy, this term still provides a good measure of relative interest over time and demonstrates the clear spike of attention on either side of the nuclear spectrum created by Fukushima.

time of the Fukushima accident. While this serves as an example of the increase in the prominence and interest by the public of nuclear issues, it does not sufficiently explain policy changes. What can be surmised from the sudden spike is that public interested peaked follow Fukushima, but not how this interest translated into policy change. However, the sudden attention to a particular issue can allow for for an opening or opportunity in new policy ideas to be proliferated, which is why having a substantive spike in interest on the issue can be so important. Where this opening is created can bring a renewed sense of importance and curiosity to the issue as it is in the news and at the forefront of the public's mind and agenda. Even if the effects of the renewed interest do not last long, it may be time enough for the subject to come under reconsideration and lasting sentiments to settle.

Additionally, in looking at worldwide trends in attention to nuclear issues, there are country-specific reactions to the crisis at Fukushima. While the worldwide outlook demonstrates an overall dramatic increase in the attention given to nuclear issues around the time of the Fukushima accident, there is variation in this observed spike in interest across countries. From a different angle, the varying interests some states have in nuclear matters can be observed by the spike of interest from the public in the periods prior to, during, and after the Fukushima accident. This intensity, demonstrated in the figure below, can be seen in Google Trends tracking of "nuclear" searches is by country. The shading on the country in the graphic indicates the search volume, with darker shaded areas having more concentrated searches for nuclear than lighter shaded areas. Certain areas had a very strong reaction to the nuclear accident at Fukushima. Compared to the period prior to the accident, relatively higher interest can be seen in many countries, such as Canada, Australia, Spain, India, Mexico, the US, Chile, and the UK. Unsurprisingly, many of those places have a very vested interest in nuclear energy. As shown in the figure below, searches regarding nuclear intensified during the period that covers the Fukushima accident compared to the period before it. Furthermore, interest in nuclear dies down in the years that follow the accident. What can be surmised from this motion is that the accident “peaked” the public interest in nuclear issues in many countries.

Other countries responded negatively to existing nuclear energy plans after the accident, such as Chile, Belgium, and Spain. The longstanding antinuclear movement in these countries had been making strides before the accident and were revived by the bad publicity the Fukushima accident brought to nuclear energy overall. Others countries displayed interest in nuclear matters after the Fukushima accident, not necessarily because public attention was focused on getting rid of nuclear power, but because of their strong investment into the nuclear cycle. Some, like Australia and Canada, are longstanding exporters of uranium and nuclear industry leaders, so market changes in a big industry would be of considerable interest to many. Others, had either large numbers of viable nuclear power plants, or interest in expanding nuclear power plants in the future. The US and the UK have well established nuclear power capacities and based on available evidence, will continue to do so for the foreseeable future. In contrast, India and Brazil are major developing countries that may need to expand and rely on nuclear energy to meet their growing demand for electricity while reducing their carbon emissions. All of these places that showed intense interest in nuclear concerns from the Fukushima have reason to be vested in the future prospects of nuclear energy.

Figure 1.2: Google Trends Searches of “Nuclear” for Pre to Post Accident Periods

Immediate Pre-Fukushima Period
(January 2010 – August 2010)

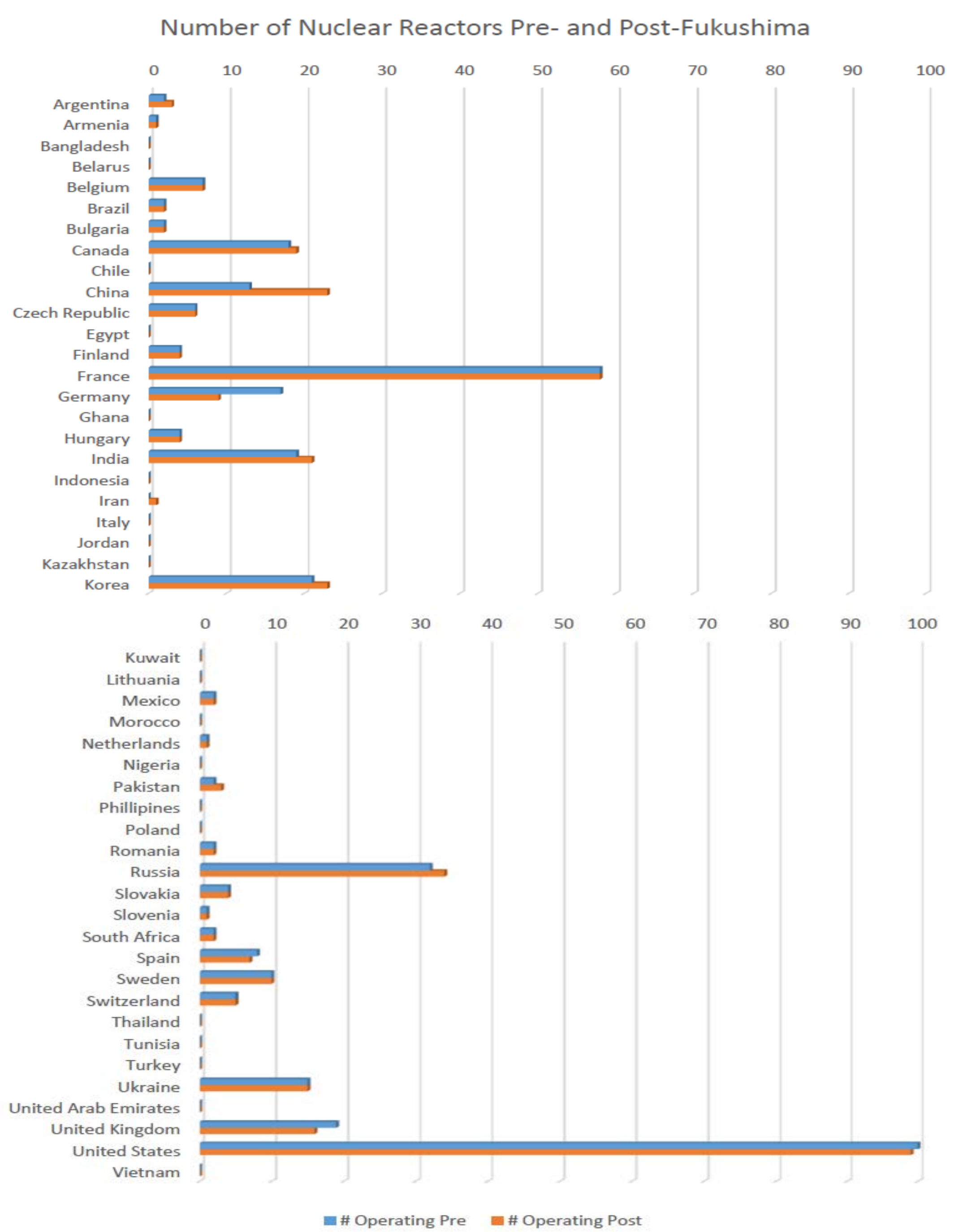
Fukushima Accident Period
(September 2010 – April 2011)

Recent Period
(January 2016 – August 2016)

As can be seen from the previous two figures, there has been a significant increase in the attention given to nuclear issues resulting from the accident at Fukushima and this attention has not directly contributed to a clear decision outcome on nuclear energy policy. Both on the whole and in individual countries, the public has taken an interest in nuclear matters because of the prominence from the widespread accident and its resulting physical and political fallout. Unexpectedly, how that attention translates into policy change is unclear. In some cases, the increased attention results in public mobilization against nuclear energy that fosters antinuclear policy change. Whereas in other cases, attention toward nuclear issues increased, but instead of pushback against nuclear energy, the national capability on nuclear energy has advanced. The direction of the policy movement following Fukushima accident remains unclear as to whether it caused policy retraction or advancement on nuclear energy. Therefore Fukushima itself is not a direct cause of policy change. Instead, the accident opened a window of attention and interest in nuclear energy that can be utilized to foster the environment within which policy change can take place.

Conventionally, it would be expected that a nuclear accident would have universally negative effects and an enduring legacy in all nuclear power countries. However, as discussed above, the actual impact of Fukushima has not been uniform. A nuclear accident potentially shows the most devastating consequences of nuclear energy production. In the aftermath of its destruction it could be assumed its witnesses would desire pausing or ending nuclear production. There are plenty of examples of countries that have pulled back from nuclear energy in the aftermath of accidents, particularly the Fukushima disaster, notably: Sweden, Italy, Germany, and Vietnam. However, there are others that have expanded their nuclear energy capacity in the period following the accident, among them: India, Russia, China, and South Korea. These countries go against the conventional wisdom that nuclear accidents will have a negative effect on the potential for nuclear energy in the future. In reality, the outcome is a complex one. In the figure below, the number of operating nuclear reactors in countries that have an existing or previous capacity of nuclear energy is charted prior to and after the Fukushima accident.

Figure 1.3: Nuclear Reactors Prior to and After Fukushima Accident



Rather surprisingly, in more cases than not, countries added rather than removed reactors to their nuclear power plants during the time period prior to and after Fukushima. As seen in the figure, there is a complexity underpinning the drive for nuclear decision-making in light of a major nuclear accident. But what motivates certain policy changes in some cases but not others? Why would some countries be heavily swayed by the impacts of the accidents on the policy landscape while others are unaffected or even ignoring of the potential negative consequences of it? While it would be expected that there would be a scale back from unclear energy following an accident, and some countries do make policy choices against nuclear power, there are other countries that choose to expand upon their nuclear power generation and plans.

The academic literature on nuclear energy has been largely concerned with the risks versus rewards of its generation, particularly in light of high profile accidents. This dissertation project contributes to the current understanding and study of the nuclear energy by adding key implications from the Fukushima accident. The Fukushima accident renewed many critiques of the potential benefits of nuclear power. Prior to the accident, the outlook on nuclear energy had many optimistic proponents who saw nuclear on the verge of a renaissance, just poised to expand due to the growing global demand for electricity, need to reduce carbon footprints, and opportune market conditions. But, with the shock of a multifold accident in a country reputed for some of the highest industrial safety standards and disaster prevention planning, the far reach of the fallout to places thought immune of the negative effects, and the enduring legacy of cleaning up the site have readjusted the attitude and expectations for the future of nuclear power. After the most recent nuclear accident at Fukushima, the debate about the future of the risks or rewards of nuclear energy have remained much more agnostic. In turn, much of this debate will shaped by the lasting impact and way in which policymakers and the public they must respond to view the Fukushima.

1.4 The Argument in Brief.

This dissertation relies upon "focusing events" to provide answers to how Fukushima impacted nuclear energy policy. In the policy literature, sudden and large scale events such as the Fukushima disaster are conceptualized as focusing events. These are external shocks that have a quick onset and are relatively uncommon and harmful, often in the form of a disaster or a crisis (Kingdon 1984; Baumgartner and Jones 1993; Birkland 1998, 2006; Mortensen 2007). In order for policy change to occur, an event must be large enough and rare enough that it generates a shift away from the predominant thinking and fosters a change in the agenda. The focusing event highlights a policy failure and the opportunity is present for policy change, that is, to correct this failure. In such a shift, groups and policy entrepreneurs promote their ideas in a newly found context that is open to a change from the status quo. While such dramatic events are commonly understood as enhancing public attention to public problems, some studies show that such focusing events in fact serve as catalysts for policy change.

Drawing on Kingdon (1984), Sabatier (1988), and Birkland (2006),[6] I argue that the Fukushima disaster acted as a focusing event for policy change on nuclear

[6] Most accounts of the focusing event literature have a causal mechanism of policy entrepreneurs that promote ideas that can lead to policy change. The approach of this dissertation, however, is less concerned with individual policy entrepreneurs and

energy, and that the outcomes are influenced to differing degrees by a set of factors that (dis)incentivize the endorsement of nuclear power in a particular country. In the aftermath of the accident, states adopted one of three outcomes in their national nuclear energy policies:

- a reversal of nuclear energy ("antinuclear" policy change)
- a promotion of nuclear energy ("pronuclear" policy change)
- status quo continuance of nuclear policy (effectively, "no" change)

As this project argues, antinuclear policy change is more likely when there are existing antinuclear advocacy groups, opportunity for political dissent, a lack of nuclear industrialization, and a pre-existing negative nuclear narrative. Conversely, pronuclear policy change is more likely to transpire when there is strong pronuclear advocacy groups, a lack of opportunity for political dissent, a strong nuclear industry, and a narrative about nuclear that is positive. These mechanisms work to change policy through a buildup of public attention and the creation of public and policy action on nuclear energy choices.

As will be described systematically in the following chapters, this dissertation will draw out the factors in the agenda-setting literature to explain how the Fukushima accident became a focusing event for policy change in national nuclear energy policy. And particularly, why, in some cases and not in others, did Fukushima "push" countries to move away from nuclear energy? Despite the existence of literature on focusing events across public policy, political science, and disaster studies, there is a lack of understanding about the underlying causal mechanisms that can explain why

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views focusing event policy change momentum stemming from social structural influences.

some governments change policy after a focusing event while others ignore the focusing event entirely or are only marginally responsive to it.

So what specifically does this dissertation project hope to contribute? Firstly, it will update the existing literature on the Fukushima accident. While the academic study of nuclear energy is often responsive to current events, nuclear analysts and policy experts are still coming to grips with the importance and contribution of the Fukushima disaster specifically. Secondly, this project will provide a quantitative examination of the parameters of policy change after a major nuclear accident. This type of analysis of the factors of policy change has not yet been widely applied within the study of nuclear accidents. Thirdly, this dissertation will provide sensitive case study analysis to draw out explanatory factors that may be missed by the quantitative analysis. I use three case studies that track the different outcomes of policy change (pronuclear change, antinuclear change, and status quo policy) in Russia, Germany, and Canada to give a greater detail to the analysis and track the more social factors and causal mechanisms at play in the development of a nuclear power program. Finally, in leveraging both quantitative and qualitative analyses in this dissertation, we are able to both explain current nuclear energy pursuance as well as offer generalizable predictions to the future viability of nuclear energy as a power source. In addition, this dissertation project aims to be policy relevant in addition to advancing in the academic literature. In sum, the above contributions ensure that this dissertation will make a novel contribution to both the academic study of policy change after nuclear accidents as well as policymaking within this same arena.

1.5 Overview of Dissertation Project.

The essential question of this dissertation project is the following: In the aftermath of a major nuclear disaster, why do some countries adopt antinuclear policy changes while others adopt a more pronuclear stance? To investigate this question, this dissertation project will proceed in the following manner:

The second chapter will provide an overview of the state of the literature related to policy changes on nuclear energy. This chapter approaches the question of nuclear accidents from an interdisciplinary stance, synthesizing knowledge from the fields of public policy, political science, and disaster studies. There are well developed approaches within each field that can be beneficial to view together, while adding the unique insights that each field has made to the study of nuclear accidents. It will examine in comparative measure the history of major globally recognized nuclear accidents at Three Mile Island and Chernobyl, as well as the emerging narrative around the Fukushima disaster. While there is an established literature, some of the major shortcomings that this dissertation will hope to contribute in rectifying include looking at how a focusing event plays out at a global level with differing country level reactions, taking a comparative investigation of policy changes related to one particular disaster type, and showing how public perception of risk can have a wide effect on policy outcomes toward nuclear energy.

The third chapter examines theoretical developments related to the study of focusing events and the framing of nuclear disasters that this dissertation project will use, as well as what it hopes to add by using them. While focusing events as a theoretical structure are not a new approach, it is not yet well established how focusing events contribute to policy change. This project utilizes the approach that focusing events open a window of opportunity that can lead to the potential for policy change. It does not mean that policy change is guaranteed, but it establishes conditions for change that may have otherwise not taken place. The exact conditions can vary greatly, but there is still a basic progression from event stimulus to problem recognition to idea generation to potential for policy change. This theoretical approach is the underlying logic to the empirical chapters that follow, as policy decisions outcomes are differentiated. The third chapter also details the commonly prevailing theoretical explanations of policy change following a nuclear accident. In the subsequent chapters, each of these explanations are held up to quantitative evaluation.

The fourth and fifth chapters provide the quantitative examination of evidence of policy change following Fukushima. Chapter four specifies the research design and methodology of the quantitative analysis. In doing so, it operationalizes and provides justification of the choice of cases, variables, and modeling. One of the most significant issues grappled with in the quantitative analysis is overcoming small-n problems since the quantitative analysis only has 49 cases. This chapter deals with these concerns and how the model takes them into account without undermining the quality of interpretation. Chapter five undertakes the quantitative analysis and modeling. In taking each of the contending explanations for policy change following a nuclear accident, this chapter looks for what explanations from the data can be shown from the Fukushima accident. Following that, the chapter uses three logistic regression models with three different dependent (outcome) variable specifications: one on antinuclear policy change, one of status quo assumption of policy, and one on pronuclear policy change. The results of the models, and their implications, are then discussed.

The sixth and seventh chapters turn to a qualitative approach to the question of post-nuclear accident policy change. Chapter six details the necessity, research design, and guiding philosophy behind the case studies. The theoretical framework is established and identifies four crucial factors in determining out-kind of policy outcome. The four factors are: the ongoing nuclear narrative within the country, strength of nuclear industrialization, opportunity for political dissent, and existence of advocacy coalitions. Chapter seven examines three “micro case studies” where each of the policy outcomes are given: pronuclear policy change in Russia, antinuclear policy change in Germany, and status quo policy in Canada. The four factors are woven throughout the analysis of each country. The historical development of nuclear energy is traced in each country immediately prior to and after the Fukushima disaster. Each case study concludes with the future outlook on nuclear policy potential.

The last and final chapter provides concluding thoughts. Chapter eight takes an overall assessment of topic of policy changes following a nuclear accident, the processes of this dissertation, and its over all contributions. Specifically of note is the policy orientation of these concluding thoughts. This dissertation aims to be accessible to policy decision makers and not just an esoteric account of this subject.

Chapter 2

THEORETICAL CONTRIBUTIONS AND LITERATURE REVIEW

This section assesses current literature in the area of nuclear energy and nuclear accidents. In particular, it reviews the literature and takes into account of where there are gaps in our understanding of policy choices following nuclear accidents. It also proposes the theoretical approach that orients this research and discusses the contributions that can be made by this project. Given the unique research questions presented by this dissertation, the literature review covers research from the fields of political science, public policy, and disaster studies. As a result, this dissertation takes an interdisciplinary approach.

This chapter is outlined as follows: first, I review the historical development of the academic literature on nuclear energy, including the most recent debate about the prospects for a global "nuclear renaissance" and the impact of the Fukushima disaster. Second, this chapter assesses the study of nuclear disasters within the context of other types of accidents/disasters, before turning to what is gained from this comparison. Third, it examines the impact of the socially constructed factors in disaster analysis, particularly those related to policy-making and the perception of risk. Fourth, it reviews the public policy literature that describes how policy change occurs, agenda setting, and the degree to which crisis dynamics influence political processes. Fifth, previous explanations for policy change in nuclear energy policy are reviewed. These explanations guide the questions and interpretations of the results in the quantitative evaluation in later chapters. Sixth, the theoretical framework of this project is put forth with an assessment of focusing events. Lastly, this chapter will identify gaps current understanding of the study of nuclear energy and policy change, and what this project contributes to the literature on nuclear disasters.

2.1 The Study of Nuclear Energy

2.1.1 *Comparative Study and Fukushima*

How do nuclear focusing events impact the study of state policy formation? What can we learn about state policy decisions from the impact of nuclear accidents? While nuclear energy represents a distinct area of policy decision-making, unpacking its policy processes offers significant insight into how states can respond to an external shock and affect substantive policy change on complex issues. Looking at nuclear energy policy, particularly after Fukushima, can enrich our grasp of overall state policy mechanisms. As Hindmarsh (2013) notes, “nuclear energy has long been a focus of social science research, representing a paradigm case for understanding relations between publics, policy, and science and technologies, including the framing of nuclear safety, and the governance of risk. Following Fukushima, questions about nuclear power were brought to the forefront of debate” (17). This project explores cases comparatively in order to analyze the degree to which the Fukushima disaster impacted policy change; but more broadly this project offers value by contributing to our understanding of how and which events can usher in policy change. A disaster is a big event which disrupts the policy landscape that has the potential to force reassessment of existing decisions, because something egregiously went wrong to cause the disaster in the first place. But even though the public consensus may hold that a disaster raises issues and causes the potential for change in a policy landscape, not all stakeholders come to the same policy conclusion after reassessment. As mentioned briefly in chapter 1, this dynamic has been observed in various countries' response to the Fukushima disaster, and is one of the many reasons the disaster itself is such a compelling example for further study.

Fukushima, provides a strong case of study to understand better how states make policy changes. As Ramana (2013) notes, "in the explosion of literature on nuclear power since Fukushima, nuclear policies in individual countries have been widely discussed. But an examination of the larger picture raises questions about why similar countries had very different responses to Fukushima, and points to underlying factors that shape nuclear policy within a country" (67). Even prior to the accident, countries had a long experience with nuclear choices. Nuclear programs take an extensive time to develop or shutdown, and many states have wavered in their support for them over time. For example, many countries, particularly in Europe, immediately responded unfavorably toward existing nuclear energy programs following the Chernobyl accident. Accidents raise concerns about risk and safety in the public's eye, and so, states must take any potential hazards into consideration while making policy choices on nuclear energy. This is particularly true after an accident raises negative public opinion – such as after Fukushima or Chernobyl. But even in light of public discontent, policy outcomes do not follow a single direction.

As news of disasters spreads quickly, global events become local ones and are difficult to ignore. An incident, especially one with negative consequences, forces questions of what might be done in one's own backyard to deal with potential issues that could arise from a similar event. Disasters, especially nuclear ones, are additionally compelling to study because their effects are not limited to the boundaries of a particular state. For example, radioactive fallout from the Chernobyl disaster contaminated nearly 14.5% of neighboring Belarus, and reached as far as Sweden, Greece, and Bulgaria.

In addition, many anti-nuclear activists and researchers see disasters as a potential for learning and policy change. Calls for accountability characterized by official investigations, blame games, political maneuvering, media scrutiny, and disaster explorations have the potential to invoke strong reactions, even in places that have not had to deal with the immediate consequences of the disaster. For example, following Chernobyl, non-contaminated countries began to re-assess their existing nuclear energy plans. With this in mind, studying the relationship between disasters and policy is critical for the field of comparative politics.

2.1.2 *Overview of Nuclear Literature*

Much of the previous research about nuclear energy from the political science field explores how elites and the public and elites form opinions about nuclear power,[7] the formation and evolution of antinuclear movements,[8] the siting of nuclear power plants,[9] and international cooperation on the peaceful uses of the atom,[10] and qualitative historical analysis related to why countries rely on nuclear energy.[11]

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[7] See Rothman and Lichter (1987)

[8] See Kitschelt (1986)

[9] See Aldrich (2008)

[10] See Barkenbus (1987) and Fuhrmann (2009).

Fuhrman (2012) assesses much of this previous scholarship as important "because it provides interesting information about nuclear energy development in one country—or a small group of countries—but it is less useful for generalizing across space and time. Moreover, many of these studies are dated and do not account for trends in nuclear power over the last several decades" (32). The issue of out of date studies is a major limiting consideration and as such it is essential to update the existing scholarship.

The academic literature on nuclear energy is divided into three phases: the 1950s through 1986 Chernobyl, following Chernobyl until the 2011 Fukushima disaster, and then onward from Fukushima. Most of the literature written prior to 1960 focuses on two main subject areas: the decision to use the bombs on Hiroshima and Nagasaki and nuclear weapons in general[12] and speculation as to the future of nuclear technology as a power source.[13] At this time, the prospects of nuclear energy were largely unknown and so this literature discusses either weaponization or the potential for peaceful applications. This duality of the nuclear debate would continue up into the 1970s and 1980s, but the OPEC oil shocks and Arab oil embargo introduced a new

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[11] For example, Nau (1974), Poneman (1982), and Solingen (1996).

[12] See Shogo Nakaoka (1951), *Hiroshima Under Atomic Bomb Attack*; Abraham Meyer (1954), *Changing Japanese Attitudes Toward Atomic Weapons*; Henry Kissinger (1956), *Nuclear Weapons and Foreign Policy*; Burr W. Lyson (1951), *Atomic Energy in War and Peace*; John Bowle (1959), *Adapt or Perish: The Dilemma of Nuclear Politics*; Stephen King-Hall (1959), *Defense in the Nuclear Age*; Pierre-Marie Gallois (1961), *The Balance of Terror: Strategy of the Nuclear Age*.

[13] See G. Wendt (1956), *Nuclear Energy and Its Uses in Peace*; Donald James Hughes (1957), *On Nuclear Energy: Its Potential for Peacetime Uses*; Werner Heisenberg (1952), *Philosophical Problems of Nuclear Science*; Dewey Larson (1956), *The Case Against the Nuclear Atom*.

sense of urgency for the testing of viability of energy alternatives, including nuclear energy. In the aftermath of these events, scholars turned their increased attention to nuclear energy policy.[14] From this point forward, nuclear weapons and nuclear energy became separate areas of study, and scholarship on nuclear power turned to questions of safety and economic viability. Following the highly publicized Three Mile Island and Chernobyl accidents, research turned to the effects of the disasters in terms of risks versus benefits and the future and public opinion on nuclear energy policy.[15]

The academic literature on nuclear energy in the most recent era has been largely concentrated on resolving the risks versus rewards of its generation, particularly in light of high profile accidents. The latest iteration of this back and forth has only been further exacerbated by Fukushima, the most recent high profile nuclear disaster. The Fukushima accident renewed many critiques of the potential benefits of nuclear power. Prior to the accident, nuclear energy had many optimistic proponents who saw nuclear on the verge of a renaissance, just poised to expand due to the growing global demand for electricity, need to reduce carbon footprints, and

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[14] See David M. Elliott, Pat Coyne, Mike George (1978), *The Politics of Nuclear Power*; Duncan Lyall Burn (1978), *Nuclear Power and the Energy Crisis*; Kristen S. Shrader-Fernchette (1980), *Nuclear Power and Public Policy*; James Everett Katz (1982), *Nuclear Power in Developing Countries: An Analysis of Decision Making*; Stanley M. Nealy (1983), *Public Opinion and Nuclear Energy*; William R. Freudenber and Eugene A. Rosa (eds.) (1984), *Public Reactions to Nuclear Power: Are There Critical Masses?*; Walter A. Rosenbaum (1987), *Energy Politics and Public Policy.*

[15] See Peter Gould (1990), *The Democratic Consequences of Chernobyl*; James M. Jasper (1990), *Nuclear Politics, Energy and the State in the United States, France and Sweden*; Christian Joppke (1992), *Mobilizing Against Nuclear Energy: A Comparison of the US and Germany*; Joseph V. Rees (1994), *Hostages of Each Other: The Transformation of Nuclear Safety Since Three Mile Island*; Peter Hodgson (1999), *Nuclear Power, Energy and the Environment.*

opportune market conditions. But this changed with the shock of a multifold accident in Japan. In particular, the public developed negative attitudes as a country reputed for some of the highest industrial safety standards and disaster prevention planning suffered such a disaster. Additionally, the fallout from the disaster to places once thought immune to negative effects and the enduring legacy of cleaning up the site contributed. Following Fukushima, the debate about the future of the risks or rewards of nuclear energy have remained much more uncertain.

2.2 Understanding Disasters and Constructing a Disaster Event

2.2.1 *Uniqueness of Nuclear Disasters.*

According to Birkland (1996), "the problems of nuclear power are considerably different from those raised by earthquakes, hurricanes, or oil spills, and the politics of nuclear power reflect its unique status in energy policy and in public policy making more broadly" (106). There are many reasons that nuclear accidents are easily distinguishable from other types of technological or natural disasters, many of which have already been mentioned above. But one of the most distinguishing factors with nuclear disasters is that they hold the possibility to devastate a large area to the degree that might never be habitable again. Unlike a tsunami that will eventually recede, or a volcano that will eventually cool, nuclear accidents cause extensive amounts of radiation that have half-lives of at least thousands of years. By some estimates, Pripyat, Ukraine, immediately adjacent to Chernobyl, will be uninhabitable for the next 24,000 years. The National Academy of Sciences (1981) estimated that the explosion of a nuclear weapon could create a lethal zone beyond the detonation site of 500 square miles. Of even more concern, but they find "the possibility of an accident resulting in release of radioactive water or emissions in the air. The frequency of incidents at nuclear power plants caused by design and construction faults and human error suggests the real likelihood of such a release." Nuclear accidents bring a unique challenge to disaster studies because of their capacity to bring such devastation, and there is as much variation among nuclear disasters.

2.2.2 *Studying Disasters.*

The field of disaster studies has developed relatively recently. Combining a host of fields, including, engineering, sociology, public policy, and political science, it emerged out of the 1960s with the development of the interdisciplinary Disaster Research Center.[16] Disaster Studies does not just look at natural events like earthquakes, floods, cyclones, or droughts, but rather the effects that these processes have on human lives and livelihoods (Nakagawa and Shaw 2004). The risk of being affected by natural disasters increased dramatically after the 1960s, and in the 1990s, the number almost doubled from the previous decade (Nakagawa and Shaw 2004). However, what has been witnessed in the last decade can be termed as "man-made" disasters, which have occurred as the consequence of human activities (see Blaikie et al (1994), Brown and Starke (1996), Twigg and Bhatt (1998). Disaster Studies tries to find useful lessons from past disasters to provide a framework for facilitating and improving disaster mitigation, response, and recovery (OECD 2004). For the purposes of this dissertation, Disaster Studies provides some important insights on disasters as

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[16] Originally out of Ohio State University, now at the University of Delaware (this author has collaborated and researched at the Center and its extensive library collection).

social catalysts, organizational decision making, the differences between natural and technological disasters, how risk perception plays out, and how conflict between stakeholders impacts events.

2.2.3 *Disasters as Social and Political Catalysts.*

While the physical or economic damage caused by a disaster are often immediately apparent, researchers and policymakers are just beginning to explore the social and political dimensions. As Tierney (2006) notes, "classical sociological research on disasters emphasized the pro-social and adaptive dimensions of disaster-related behavior" (109). In recent years, these social and political aspects of disasters have catapulted forward by both researchers and policymakers. This has been especially true in the aftermath of tragic events like 9/11, Hurricane Katrina, and the 2004 South Asian Tsunami. According to Boin, McConnell, and Hart (2008), "[disasters] have been the subject of considerable academic study. Once a disjointed, segmented set of niches within the social sciences, such writings have expanded in volume and gained coherence following major funding boosts in the wake of the 9/11 attacks"[17] (5). This increased attention has greatly enriched the study of disasters. Disasters are of interest not only to researchers and policymakers, but also to those affected directly or indirectly by them. As such, public involvement in preparedness and recovery, especially in the US after Hurricane Katrina, is now at the forefront of the public policy agenda. In many ways, Hurricane Katrina marks a major turning

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[17] A wide variety of sources exist. For an overview, see Breecher (1993); Rosenthal et al. (1989; 2001); George (1993); Farazmand (2001); Seeger et al. (2003); Boin et al. (2005) and Rodriguez et al. (2006).

point for recognizing how a disaster can have long last policy and social change. And in turning the attention to the public policy agenda, disasters are recognized as having distinctive social and political ramifications in their aftermath. After a disaster, vulnerabilities are exposed and so the public's natural inclination is to address the social and political issues that emerge.

At present, Disaster Studies is notoriously bad at comparative analysis[18], and so few existing studies exist that explore the impact an event in one country impacted another. However, several recent events have caused countries to take more notice of external disasters. The 2004 Indian Ocean Tsunami brought a sea of change not just to places that were touched by its waves, but other countries responded by making policy chances to ensure that they were better prepared (Shaw 2015). In the current literature, there are only a few similar examples. Most research on disasters as political or social catalysts focuses on operational procedures, and, again, misses out on any comparative study. As summarized by Boin, McConnell, and Hart (2008):

> The bulk of this research focuses on the managerial dimension of coping with crises: prevention and preparedness measures, critical decision making during emergency response operations, coordination of operational services, communication with the general public, and dealing with the mass media. It tends to concentrate on the functional challenge of adapting public organisations and networks to the extreme conditions that major emergencies impose. It has resulted in policy principles for risk assessment and contingency planning as well as in experiential rules and guidelines for designing and running command centres, fostering interorganisational collaboration, informing the public and managing media relations (6).

[18] This issue is addressed in the section below.

In contrast, there is much room for investigation of how political and social elements are impacted after a disaster and what room may open for any meaningful way of policy change as a state moves forward.

The study of large-scale disasters reveals flaws in the way risk management is handled. While there are generalized disaster experiences, the field has seen a division in the approaches to natural versus technological disasters. Although nuclear disasters vary greatly from other disaster types, “experience has been gained in planning, preparedness, and management of nuclear accidents through addressing real situations like Chernobyl, or fictitious situations through drills and exercises. Much of this experience is directly applicable in the preparation for and management of other, large-scale disasters” (OCED 2004, 72).

2.2.4 *Natural vs. Technological Disaster Studies*

In studying disasters, there is a clear analytical distinction between natural and technological (or manmade) disasters. Natural disasters have the potential to be incredibly destructive events, even though the processes that form them are often well understood, and perhaps even predictable. And yet, they will never be fully preventable. At best, efforts at mitigation and response can to an extent bring some element of human control and relief. Thus, the focus tends to be on more physical response efforts since, at this point, technology to fully prevent natural disasters does not exist.

Manmade, or technological, disasters can be prevented, even though they are far less predictable. As opposed to natural disasters, the fact that blame can be linked to a person or organization creates a substantial analytic distinction. The aftermath focuses on accountability and designing systems and structures to prevent a similar catastrophe. When events are closer to technology, it is easier to assign blame and approach with a need for accountability. This divide and approach between natural and technological disasters is also seen in how response to crises more generally are approached, "when… unforeseeable and uncontrollable, the amount of explaining and excusing [policymakers] have to do is a relatively limited. But when there is a widespread perception that the threat could have been foreseen and possibly avoided altogether, or that the official response after its occurrence was substandard, political leaders and officials may end up in troubled waters" (Boin, McConnell, and Hart 2008, 4).

Events closer to technology are more susceptible to blame. On this continuum, "natural disasters unfold in their own way, without significant human influence. At the other end of the continuum, …[m]an-made incidents can also be expected to proceed in way that deliberately circumvent defenses, unfolding asymmetric attacks that target important nodes in critical infrastructures or particularly meaningful cultural or political targets" (Wirtz 2013, 19). The analytical distinction is further made by Birkland (1997):

> When society seems to have formed a consensus that the event was an "act of God," such as a natural disaster or freak accident, our attention turns to what we can do to help the victims. But when the disaster is the result of human failing—poor design, operator error, "corporate greed," or "government neglect"—our attention turns to the voluntary acceptance of responsibility for an event or to the more coercive process of fixing blame. Boards of inquiry are formed, legislatures hold hearings, and reports are issued, all in the hopes of "learning something from this incident" to ensure that something similar does not happen again or, in the case of "unavoidable" disasters, in the hopes of improving our preparation for and response to disasters. These are familiar outcomes (2-3).

The key distinguishing characteristic is largely the degree to which policy makers and first responders can shape the onset, course, and consequence of events (Wirtz 2013). Technological disasters, especially nuclear accidents, bring the potential changing public opinion, the political climate, and causing significant policy changes (Wirtz 2013).

In Disaster Studies research, the natural-technological divide has recently concerned itself with how events closer to technology bring more complexity as a blame game takes shape. Freudenburg (1993) maintained that society is increasingly vulnerable to "cases where duties are not being carried out properly—whether the 'fault' is one of individual actors or of a broader system in which important responsibilities may fall through the institutional cracks" (915). He further observed that most technological disasters occur because of failures at the organizational and/or institutional levels, as opposed to individuals, and therefore it is most meaningful to look at how social relations come into play.[19] With the example of Fukushima specifically, much of the disaster emerged not just from the physical environment, but social structures and attitudes created a social environment that increased the impact of the disaster. As Zaleski (2013) argues "the root cause of the accident is not technology, but the attitude of the Japanese nuclear community (utilities, industry, bureaucracy and regulatory agencies) towards external hazards and towards the possibility of beyond-design basis accidents. Other problems relate to the relationships between players in the nuclear community and to the consensus culture of Japan" (258). Technological disasters are distinct because of the inclusion of social factors—

[19] An early foundation of this line of thought (that Freudenburg expanded greatly upon) can be found in the works of Clarke (1990, 1993), Short (1992), and Vaughan (1989, 1990).

not just being an "act of God" beyond the control of human error, but being directly caused by something within human accounting. It is not necessarily an individual wrong-doer, but institutional failure occurs because the complexity of the social structure involving countless specialized individuals and institutions which increases the risk of a breakdown in technical competency and/or fiduciary responsibility.

2.3 Socially Constructed Factors

Social construction of events following natural and technological disasters is most evident with respect to community impacts, human impacts, and event interpretation. Lack of consensus regarding the nature and extent of physical damage from technological disasters leads to individual and collective uncertainty. According to the OCED (2004), "in societies that have reached very high safety and security standards, large-scale disasters can cause considerable anxiety and loss of confidence among the population" (15). When there is no collective definition of reality, such as in the wake of a technological disaster, individuals are forced to construct and reconstruct their own realities. One result of this process is social disruption, which emerges in the form of a corrosive community. In contrast, a therapeutic community is more likely to emerge following a natural disaster (Ritchie 2004). This difference between corrosive and therapeutic community is critical. Technological disasters tend to create a "corrosive" community in which a lack of consensus is predominant (Freudenburg and Jones 1991; Gill and Picou 1991, 1998; Kroll Smith and Couch 1991), whereas natural disaster research suggests that long-term social and psychological disruption occurs rarely.[20] Technological disasters provide fertile

[20] See Drabek (1986) for an overview.

ground for disinformation and rumors, which have the potential to cause panic, confusion, and disenfranchisement. The public's trust and consumer and investor confidence are key ingredients of recovery (McEntire 2000, OECD 2004); they need to be strengthened through credible communication and effective action. Establishing this credibility requires a long-term dialogue among stakeholders, which has often been neglected in the past (OECD 2004).

This social construction of accountability and learning following an event also stems from the distinction between natural versus technological disaster types. Social construction involves what Deborah Stone (1989) calls "causal stories," in which "situations come to be seen as caused by human actions and amendable to human intervention" (281). In addition, "since our cultural understanding of accidents is centrally concerned with moving interpretations of a situation from the realm of accident" to a realm suggesting negligent or willful human causation (Stone 1989, 284). For example, Stallings (1995) illuminates this related to the threat of earthquakes:

> There are no villains in claims about the earthquake threat. Natural forces and faceless social processes combine to cause earthquakes, not specific individuals or even specific types of individuals. Claims contain no hated symbol of injustice, no image of evil personified. There is no terrifying menace like the irresponsible "killer drunk" behind the wheel or the stranger who preys on innocent children. There are no callous and greedy corporate executives who disregard safety for the sake of profits. No one points a finger at the System for placing people at risk. (30)

Vastly different with nuclear accidents, it is not just the physical damage or injury brought by the event that gives attributes to the event, but the perception of risk and interpretation by the largely unscientific public. Nuclear events can largely be reduced to simple, graphic, and familiar symbolic packages. Birkland describes how this process played out with the Three Mile Island accident:

After the Three Mile Island (TMI) nuclear power plant accident, news photographs and editorial cartoonists seized upon the hourglass-shaped cooling towers of the TMI plant (a design element shared by many plants) as an easily understood signifier of nuclear power and its dangers. The cooling tower symbol was used because it is the most prominent structural feature of most nuclear power plants, although gas and coal-fired plants also use similarly shaped cooling towers. A more strictly accurate depiction of the dangerous part of a nuclear plant—the reactor containment structure—was not used as a symbol because it is a comparatively small part of the plant that is less prominent and recognizable. Since symbols are "shortcuts" or "stereotypes," they must be easily recognized if they are to have power (1997, 12).

There are many possible constructions that compete with each other to tell the story of why a problem is a problem, who is harmed or help, fault, and potential solutions (Schneider and Ingram 1993; Stone 1989), and there is a critical distinction with nuclear and other types of technological disasters.

2.3.1 *Policy Making.*

Policy making processes are also influenced by socially construed factors. Research emphasizing the social construction of policymaking focuses on the socially constructed nature of policy and the degree to which it is shaped by perceptions and intersubjective meaning-making. These constructivist types of approach are not free of criticism. Sabatier described constructivist methods as "nonfalsifiable" and their ideas as "free-floating and unconnected to specific individuals, institutions, or socio-economic conditions" (1999b, 11). However, looking at nuclear disasters through the lens of social construction helps us to understand how problems and events are not simply objective, obvious problems that automatically gain attention simply because they are compelling issues. Rather, there are usually many different, plausible ways to conceive of issues, of which only a few dominant interpretations emerge (Birkland 1997).

An important element of politics, especially related to agenda setting, relates to how stories and symbols are framed as public issues by participants in policy making and then propagated to the public. Groups adopt, expand, downplay, or co-opt symbols to promote their preferred dialogue and interests (Birkland 1997). Why are symbols important, especially to studying nuclear issues? Birkland (1997) notes that "symbols condense complex ideas into easily understood, easily transmitted ideas, in which the meanings of the symbols and the underlying ideas are generally shared by the propagator of the symbol and the recipients" (12). The details of nuclear events are generally complex and not well understood by the public at large, and so those who synthesize this information into something digestible or symbolic gain substantial power. In large part, "social constructions of risk and safety, surrounding issues of nuclear weapons proliferation, economics and politics, and the dynamics of technological controversy condition our understanding of the role and prospects of nuclear energy, in addition to contemporary rapid economics, technological, political and ecological transitions" (Hindmarsh 2013, 17). Furthermore, as Hubbard (2014) points out, a deep-seated fear of nuclear radiation is the single most important driver of the politics of nuclear energy. In many ways, this fear creates a misplaced hysteria around the perception of the risk of nuclear energy and in turn, makes the politics of technological decision-making divisive.

2.3.2 *Perception of Risk.*

As explained by Connor (2012), societies often incorrectly calculate the odds of disasters and their expected impacts, as such calculations are difficult and usually hampered by the lack of precise information about the recurrence rates of catastrophic events and the potential magnitudes of these events. The intricacies of nuclear accidents only compound this problem further. No two nuclear accidents are exactly alike and within a single accident variation is substantial. This all leads to serious problems with how the chance of disaster is understood both by the public and policymakers. Perry (1981) points out that given the highly technological aspect of nuclear disasters, few fully understand them, which raises considerable arguments about how we define "danger" and undertake appropriate protective measures. According to Kasperson (1995), even the use of probabilistic risk assessments in nuclear emergency response is problematic because they lack clear objectives and are riddled with inconsistencies (165).[21]

Nuclear disasters are low probability, but high visibility events, which makes them a highly imperceptive phenomenon to those trying to understand them and assess the basis of risk. As Daniels, Kettl, and Kunreuther (2006) explain, on a general level:

> Compounding the problem is the difficulty individuals have in considering the probabilities when making their decisions. It is not easy to assess low-probability events, and people often disregard them.

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[21] More on issues of risk assessment and perception below.

> There is ample evidence that people often do not want to consider data on the likelihood that an event might occur, even when the information is available to them. Only after a disaster do most people pay attention to it, and then they overestimate its likelihood. For example, when a single, rare disaster attracts a great deal of media attention, individuals focus on the consequences of the event and behave as if it will happen again in the future (6-7).

But when it comes to complex nuclear disasters, policymakers and researchers face challenges given that the probabilities of accident recurrence are not well developed or understood. A better understanding of the concept of risk likelihood, and its application to nuclear instances, would greatly advance improved calculations of risk in a disaster.

Understanding risk is a critical concept to the study of disasters. Research about risk perception arose from observations that a gap exists between how the public and experts differently perceive levels of risk. Many theories have been proposed to understand why different people make different estimates of the dangerousness of the risk of a particular event or behavior. Early work emphasized rationalist approaches to understanding how individuals respond to risks (i.e., weighing information before making a decision), but outside of economics and engineering this research was of little applied use. Furthermore, the rationalist approach that additional information alone shifts perceptions has been rejected by numerous studies (Douglas 1986). However, Starr (1969) revealed that based on the "preference approach" some levels of risk are societally acceptable. For example, people will accept risks 1,000 greater if they are voluntary (e.g. driving a car) than if they are involuntary (e.g. a nuclear disaster). More recently, three major strands of study in risk perception have emerged: psychological approaches (heuristics and cognitive) that continue using rational choice theory, interdisciplinary approaches (social amplification of risk framework) which combine social psychology and behavior economics, and anthropological/sociological approaches (cultural theory) that promotes social organizational factors.[22]

The assessment of risk is important, but when looking at the actors and their construction of the nuclear issue, understanding the perception of risk is most important. Roberts (1984) delineates this critical difference: “Risk assessment is a branch of engineering and involves an attempt to arrive at a technical consensus independent of individual preference; risk perception involves the study of people’s opinions and has its roots in applied psychology and sociology” (75). Risk assessment is dynamic in that it “not only [specifies] the likelihood and potential sequences of disasters of different magnitudes and intensities but also undertake systematic cost-benefit analysis to prescribe a set of actions that should be taken in response to those risks” (Daniels, Kettl, and Kunreuther 2006, 5-6). The way in which risk gets communicated can largely sway this perception, as it:

1) informs and educates the public

2) improves of hazard preparedness and effectiveness of accident warning systems

3) and formulates policy solutions and could play an important role in the resolution of conflicts about nuclear energy (Van de Pligt 1992, 151).

Perception of risk has direct and negative effects on attitudes toward nuclear energy and has been shown to be the strongest predictor of the public’s willingness to take action against nuclear power (Whitfield et al. 2009). As Van de Pligt (1992) says, “The large uncertainties involved necessarily push the evidence out of the realm of

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[22] For more on each of these approaches, see Kasperson and Kasperson (2005), Douglas (1986), Douglas and Wildavsky (1982), and Slovic (2006).

'facts' and into the realm of 'opinion'" (159). According to Roberts (1984), with nuclear accidents problems arise from the "major discrepancy between the calculated health consequences, which will be minimal, and the perceptions of the risk shown by many local inhabitants (and the media), which caused much mental distress" (67). Additionally, according to Yeo and her colleagues (2014), the public perception of risk related to nuclear power is further complicated by the several stages of risk in the supply chain of nuclear energy, e.g, the mining of nuclear materials, material transportation, production of power, and storage and disposal of waste[23] (e.g. Slovic 1987, Slovic et al. 1991 and van der Pligt 1992). It is not surprising then that relatively little research has been done on methodological and procedural aspects of risk assessments and their relationship to policy decisions (Van de Pligt 1992, 159).

Understanding the transmission of risk from one stakeholder to another is critical to determining how actors make a particular decision about nuclear energy. According to Zaleski (2013), "above all, the public perception of risk – a socio-political reality – is much more significant for nuclear energy than for other energy sources" (259). There are many reasons for this distinction, but most come back to uncertainty about nuclear technology (differences between a nuclear power plant and a nuclear bomb), radiation and its effects. "Historically, expressions of public concern regarding nuclear power have been dominated by comments concerning the safety of the technology. Historically this dates back to the very earliest days of nuclear power in the 1950s… In the 1950s and early 1960s anxieties about nuclear power were overshadowed by fears of nuclear war and nuclear weapons" (Nuttal 2005, 65). Public

[23] For a comprehensive overview of public attitudes towards nuclear waste, see Jenkins-Smith (2011)

perception shifted over time against nuclear energy, and the problem seemed to be a difference between scientific facts and an exaggerated public perception of the dangers. Risk assessment in the nuclear realm varies greatly between ordinary citizens and experts in the field. And it brings with it challenging political issues: “Elected officials often face conflicting imperatives: citizens demand attention to some risks due to fear, dread, or catastrophic potential while experts feel the risk is not worth considering because of the small chance of its occurrence… And, of course, there is the challenge of how elected officials will mediate between these conflicting imperatives in the context of political cycles” (Daniels, Kettl, and Kunreuther 2006, 6).

And there is substantive concern about the paranoia towards nuclear power in light of accidents like Fukushima. As explained by Chan and Chen (2011) shortly after Fukushima:

> the psychological and historical origins of radiation risks contribute[d] to the Great gap between public perception of radiation risks and expert risk assessments; this results in public perception of nuclear power as a catastrophic technology. Fears of radiation are exceptionally high among laypeople because radiation is a colorless, odorless, and invisible hazard that can cause cancers and death. The failure of nuclear power technology in some of the most technologically advanced countries—namely, the United States (Three Mile Island), the former Soviet Union (Chernobyl), and Japan (Fukushima Daiichi)—demonstrates that public fears of nuclear power are rational concerns rather than irrational hysteria (406-7).

German Chancellor Angela Merkel commented that Fukushima “has forever changed the way we define risk,” and there are many others who now do not trust the current approach to risk assessment (Elliot 2012, 81). With Fukushima specifically, much of the primary issue at stake was a large misunderstanding of the existing risks. Hindmarsh (2013) concurs on the perception of risk/safety and impact on nuclear energy policy that the disaster continues to play, as “Fukushima, at the least, will play a strong role not only in future demands of what constitutes safety in nuclear power, but more broadly in the debate about whether as an institution, the nuclear industry is to be sufficiently trusted” (17). When looking at the different policy responses to nuclear energy in the aftermath of Fukushima, the concept of risk and how it has played out across various national contexts helps analyze the variance of responses of the public and of policymakers.

Across the literature on risk perception, failures following a disaster bring increased attention to addressing risk and creating better systems in the future so that a similar disaster does not happen again. Following a disasters, scholars almost always call for building better risk assessments and increasing education of the pubic and policymakers. The divide between the largely uninformed public and policymakers and technological experts only creates more conflict between stakeholders and causes a false sense of the true probability of risk. This can be especially seen in nuclear disasters. Connor (2012) argues that Fukushima highlights the need to improve quantitative literacy in natural hazard assessment as a basic requirement for improved decision-making. According to Connor (2012), “a critical understanding of natural hazard assessments requires a sophisticated perspective on the mathematical and statistical tools used to estimate the odds of disaster, and the roles of data quality, model development, and subjective probability in estimation of uncertainty” (2). There is much work yet to be done on improving comprehension of risk, and in large part disasters result when risk is improperly understood (Hurricane Katrina, for example). Daniels, Kettl, and Kunreuther (2006) agree that public and private decision makers need better risk assessments, and moreover when disaster strikes there is an “opportunity to look at the entire public-private systems for addressing risk, and perhaps build better ones” (1).

2.4 Public Policy: Understanding Change After Critical Events

2.4.1 *Public Policy Literature*

Scholars argue that no research has yet developed a theory fully explaining the causal mechanisms of crisis–policy change (Hart and Boin 2001, Nohrstedt and Weible, 2010). At present, Kingdon’s (1995) multiple streams model, Baumgartner and Jones’ (1991) punctuated equilibrium model, and Birkland’s (2006) event-related policy change model are the three established theoretical contributions about crisis and policy change. Although there is overlap across the three models, each differs in both its primary dependent variable and the causal process for explaining policy outcomes.[24] Research exploring what causes windows of opportunity for major policy reforms is not new, but it has not looked at crisis-induced policy outcomes or the reasons as to why some events result in major policy change while others do not (Birkland 2006, Minstrom and Vergari 1996, and ‘t Hart & Boin 2001).

Kingdon (2003) developed the “Multiple Streams Framework” based upon Cohen, March and Olsen’s (1972) “garbage can model” of organizational behavior. It is used to explain agenda setting in the policy process and is comprised of three streams that operate interdependently of one another. First, the “problem stream” contains ideas about various problems. The problem stream involves persuading policy makers to pay attention to one problem over others (e.g, agenda-setting).

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[24] Hansén (2007), Schlager (1999), and Zahariadis (1998).

Second, the “politics stream” contains electoral processes as well as public opinion. The politics stream refers to political factors that influence agendas, such as changes in elected officials, political climate or mood, and the voices of advocacy or opposition groups. And finally, the “policy stream” contains all the ideas and solutions to possible problems and strategies for them to be addressed. Policy proposals will rise to the top of the agenda when the associated problem is recognized by stakeholders through data or focusing events. Success is more likely if solutions are perceived as technically feasible, compatible with policymaker’s values, reasonable in cost, and appealing to the public. According to this theory, in order for issues to reach the policy agenda, at least two streams must come together at the same time to create a “window of opportunity”. Zahariadis (2007) explains, “During open policy windows persistent policy entrepreneurs, who constantly search for solutions to important problems, attempt to couple the three streams. Success is more likely when all three streams are coupled, conditioned on the type of window that opens, and the skills, resources, and strategies of entrepreneurs to focus attention and bias choice” (78-79).

Following Kingdon’s Policy Streams model, Sabatier developed a subsequent approach: the Advocacy Coalition Framework (“ACF”). In the ACF approach, interest groups are organized in policy communities within a given policy domain which contains advocacy coalitions that self-organize around shared beliefs. Policy brokers seek to make compromises among advocacy coalitions. Here, the focus is on the interaction of advocacy coalitions and policy change is a product of the competition and interaction between these coalitions. Though policy change can take a long time, there are stable (i.e., policy problem, distribution of natural resources, and cultural values and social structure) and dynamic (i.e., changes in socioeconomic conditions, technology, public opinion, governing coalitions) influences. Scholars have praised ACF because it helps to explain policy change through policy-oriented learning and external events.[25] However, others criticized the model for overlooking the role of public opinion in public policy (Jordan and Greenway 1998), the stages of the policy cycle (Marzotto et al. 2000; Olson et al. 1999), and single external event change (Smith 2000).

As a third approach, Baumgartner and Jones propagated the Punctuated Equilibrium model. In their explanation, policy change isn't incremental, nor is it in a state of constant flux. Rather, the balance of political power between interest groups is relatively stable over long periods of time, however, this balance of power can shift for two reasons: the change in public understanding of policy problems and the balance of power between groups seeking to fight entrenched interests. As issues get defined in the public discourse in different ways, and these issues rise and fall in the public agenda, and existing policies can be either reinforced or challenged. When reinforcement occurs, the status quo is entrenches and policy will only change incrementally. When polices are questioned, it creates an environment for major reversals.

Punctuated equilibrium has been applied to nuclear power policy. In *Agendas and Instability* (1993; 2009), Baumgartner and Jones use a case study of US nuclear power. In the early years of the case study, the government built public enthusiasm for nuclear power by presenting it as a solution to several problems including reducing energy bills, minimizing dependence on other countries for oil, reducing air pollution,

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[25] See Andersson (1999); Brenton et al. (2006); Elliott and Schlaepfer (2001); Eberg (1997); Kübler (2001); and Lertzman et al. (1996).

and providing for employment and economic activity. This positive image, and general sense among the public that the policy problem was solved, stabilized nuclear policy making. This was largely unchallenged until the environmental and safety movement of the 1970s which created a new, negative portrayal of the nuclear solution to generate concerned interest in new venues, including the courts, congressional committees and, particularly following a major accident at Three Mile Island, the public. The negative image of nuclear power became dominant for decades as nuclear expansion slowed and a focus turned to increased regulation.

2.4.2 *Agenda Setting*

This dissertation fills a critical gap in the study of agenda setting and policymaking. Focusing events are often cited as important to agenda setting, but there is little research on how and why these events are important. Political scientists cite agenda setting as an important factor because "the definition of the alternatives is the supreme instrument of power" (Schattschneider 1975, 66). Agenda setting is the process by which issues gain greater mass and elite attention, and how the ideas and direction of the agenda is fixed. Birkland (1997) reminds us that "if we understand agenda setting as an important element of group competition, the importance of this idea, and of studies devoted to understanding agenda setting in particular contexts, becomes much clearer" (7-8). Group competition is fierce because the agenda space is limited by these constraints on information processing, so that no single system can accommodate all issues and ideas (Walker 1977; Baumgartner and Jones 1993; Cobb and Elder 1983). The competition in agenda setting is both about raising an issue on the agenda and about propagating the preferred story about how a negative condition came to light or how the problem may be prevented in the future (Stone 2002).

Agenda setting is concerned with streams of influence and where power is located "by following how issues flow through the system—how issues attention by one actor or institution is followed by and leads to issue attention by another actor or institution" (Green-Pedersen and Walgrave 2014, 9). This agenda setting process is highly social and involves the interaction of many participants. The agenda setting "is most often led by the most active and knowledgeable participants, who form advocacy coalitions, with sometimes less informed and more episodic participation by actors whose entry into the policy community is triggered by the focusing event" (Birkland 1997, 16). In effect, the policy agenda may be seized by someone who can alter the direction of policy choices based in large part upon how power, influence, and message are used.

Kingdon (2003) argues that agenda setting is driven by two broad phenomena: changes in indicators of underlying problems, which lead to debates about whether and to what extent a problem exists and is worthy of action; and focusing events, or sudden shocks to policy systems that cause attention, agenda change, and potential policy change. Kingdon states that these events "simply bowl over everything standing in the way of prominence on the agenda" (2003, 96). Also, the focusing events highlight a policy failure and the opportunity is present for policy change, to correct this failure.

2.4.3 *Change After Crisis*

A crisis can interrupt the normal operation of a given domain and force an evaluation of the factors that led to the crisis developing in the first place. Stanford economist Paul Romer is largely attributed with saying “a crisis is a terrible thing to waste”. No doubt, this attitude is adopted because there are few other times when an event may stirs up issues and forces them into the spotlight. Crises are “critical episodes marked by a sense of threat and uncertainty that shatters peoples understanding of the world around them” (Boin, McConnell, and ‘t Hart 2008, 3). Furthermore, a crisis is an episodic breakdown of familiar symbolic frameworks that legitimate the pre-existing sociopolitical order (‘t Hart 1993). Political elites and organizations, more than citizens, have to be held accountable for their behavior, since they are the locus of pre-crisis policy decisions (Boin, McConnell, and ‘t Hart 2008). According to Rose and Davies (1994), accountability is a core process in policy change as officeholders render an account of their actions prior to and following a crisis. Where these accounts are debated, judgment is passed and possible sanctions administered (Bovens 2007). A crisis is a game changer that brings up the unexpected and necessitates an immediate response. Both Public Policy and Disaster Studies research crisis-induced change because it underlies the political processes that are forced into play after a focusing event. This dissertation builds upon both disciplines.

A disaster often causes in an instant what years of interest group activity, policy entrepreneurship, advocacy, lobbying, and research may cannot: “elevate an issue on the agenda to a place where it is taken seriously in one or more policy domains” (Birkland 2006, 5). Policy evaluation typically occurs at routine and pre-planned points, but a sudden event disrupts this cycle. Change may form out of new ideas that came from intelligent reflection and experimentation. Reform might come from political posturing as embattled policy makers under critical scrutiny after a crisis. Furthermore, policy change may occur when a shift in the balance of power between various coalitions of stakeholders who are engaged in ongoing struggles about particular policies (Sabatier and Jenkins-Smith 1993).

Change that happens over a long period is often the result of the broader ebb and flow of social and economic conditions, but sharp, sudden events can accelerate the dynamics of change (Birkland 1997).Prior to a disaster, the status quo assumes that systems are working, and when disaster strikes belief in the status quo is shaken. In looking at nuclear energy policy, change generally occurs slowly, but when an accident occurs, the public demands immediate changes. Glaser (2012) contends Fukushima has caused the need for states to accommodate rapid change in nuclear energy policy.,Understanding the instruments of rapid policy change after a given crisis is something that needs more attention (Birkland 1997). There is much empirical work that remains to be done in order to explain crisis-induced policy outcomes (Nohrstedt 2008).

2.5 Explanations for Change in Nuclear Policy

Following a nuclear accident, states tend to re-evaluate existing policy. Prior to proposing my own research framework, below I view the existing research about why states advance or abandon their national nuclear energy plans after a disaster strikes. Existing scholarship views policy change through the following frameworks: geography as a proximity factor, the public opinion factor, similar regime or institutional design, length of time to the accident, energy security and climate change proponents, imposing economic costs and emerging alternatives, and technological or military advancement. In turn, I will look at the basis of each of these explanations for why a nuclear accident may or may not have an impact, before proposing my own theoretical framework.

2.5.1 *Factors*

- *Geographic Distance Factor*: Following a nuclear accident, states within close geographic proximity enact policy changes

In an interdependent world, an event that takes place in one country can have significant effects on others. When it comes to nuclear energy planning, policymakers must concern views beyond those of domestic stakeholders. With environmental concerns, like nuclear fallout, decisions from policymakers can have significant transnational ramifications. Previous examples of nuclear accidents show this point clearly. Fukushima's cost has been estimated to be approximately $235 billion making it one of the world's greatest disasters and radioactive particles reached as far away as Iceland (Sedghi 2011). The Chernobyl accident left long-lasting damage as well and impacted parts of Western Europe (Geras'kin, Fesenko, and Alexakhin 2008). In looking at the consequences of far reaching disasters, it is suggested that these accidents, which cross international borders, have a greater impact on policy changes than accidents contained nationally, like Three Mile Island (Nuttal 2005).

There have been some empirical explorations of the effect of distance on development of nuclear energy after a nuclear accident, but these studies are limited (in large part because nuclear accidents are rare) and most focus on a single country case.[26] Csereklyei (2014) quantitatively studied the impact of Chernobyl, and found that "an accident is likely to have a negative and long lasting impact in the country where it happened, and possibly in countries that were affected by the direct consequences, such as nuclear fallout" (26). Indeed, many former Soviet satellites have not forgotten the Chernobyl accident, such as Belarus, which had radioactive materials spread across nearly one-quarter of its territory, and still have a severe "allergy" to all things nuclear (Loukianova 2008). Likewise, Fuhrman (2012) concurs that "proximity to a major nuclear accident could also influence the degree to which it dissuades civilian nuclear development" (40). But even so, the connection between proximity to an accident and policy change remains unclear. Yamamura (2013) found through OLS modeling "that even when a disaster occurs in a distant location and has no physical impact on a person's health, it can still have a critical influence on their views and, in turn, the direction of policy." (363) The geographical effect of nuclear accidents has been explored to some degree, but the results are not consistent.

There is a need to study this geographical effect with the recent example of Fukushima and its potential for comparative study. As Kim, Kim, and Kim (2013) argue, the Fukushima disaster presents "an important opportunity to study the effect of distance from the site of a nuclear accident on public acceptance of nuclear energy" (823). With the jury still out on the impact of geographic distance on policy choices following a nuclear accident, the case of Fukushima offers new evidence to help understand this factor.

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[26] See Choi et al. (2000), Corner et al. (2011), Katsuya (2001), and Liu et al. (2008).

- *Public Opinion Factor*: Policy change follows a nuclear accident when the public is active about their policy preferences and able to significantly sway policymakers.

Public opinion on nuclear issues can be a driving force behind many nuclear policy choices. As Siegrist and Visschers (2013) note, “studying public acceptance of nuclear power is considered to be crucial for making sound policy decisions” (116). There has been a lot of nuclear policy research that focuses on public opinion and acceptance of risk.[27] One understudied issue at play with the role of public opinion is the role of the state in taking and directing public opinion. As Kim, Kim, and Kim (2013) argue, “public acceptance of nuclear energy is highly correlated with a government's political decision-making. Identifying the fundamental issues that affect public acceptance of nuclear energy and considering its country's unique technological, industrial, and safety status regarding nuclear energy will help each government establish a better national energy policy” (828). In large part because of the lack of knowledge about nuclear-related issues, public debate and following decisions are largely left to those who can “frame, direct and seek to influence nuclear policy without the inconvenience, or the benefits, of sufficiently rigorous political and social participation from fully informed citizens and others. As a consequence, those with views tending towards the extremes of the policy continuum increasingly dominate national nuclear policy debates and discussions” (Hubbard 2014, IX).

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[27] See Siegrist (2013), Siegrist and Visschers (2013), Yeo et al. (2014), Teräväinen, Lehtonen, and Martiskainen (2011), Srinivasan and Rethinaraj (2013), and Stoutenborough, Sturgess, and Vediltz (2013), Kim et al. (2013).

In fact, there are some cases where the weight of public opinion following the Fukushima accident influenced policy. After Chernobyl, public backlash fostered a public antinuclear movement, which effectively led to several successful referendums against nuclear power in several countries [name them?]. Precipitously, public opinion on nuclear power fell worldwide following the Fukushima accident. And yet, the degree to which there has been a substantive the public outcry against nuclear power since Fukushima remains unclear. As Kessides (2012) says, “like all past nuclear crises, Fukushima will raise the stakes for advocates, foes, and regulators alike. In most countries, public opinion is shifting in a more critical direction against nuclear power. And yet it would be decidedly premature to conclude, as some critics have been inclined to, that this is the end of nuclear power” (206).

- *Regime Type Factor*: Policy changes following a nuclear accident are more likely in domestic regimes with openness and accountability to the public.

The domestic context and political fallout of a state’s political system can hold the keys to policy behavior after a nuclear accident. For example, public opinion is thought to have more impact in democracies because leaders can be voted out at the next election if they pursue policies that are domestically unpopular (Bueno de Mesquita, Smith, Siverson, and Morrow 2003). Furthermore, because democracies have principles of freedom and openness, it might be easier for antinuclear movements to shape policy (see Kitschelt 1986). Likewise, regimes that are not democratic may be able to more effectively control the flow of information about an accident and stem the effectiveness of an antinuclear movement, like China may have tried in the aftermath of Fukushima. Empirically, scholars have only recently begun to take account of regime type reactions to nuclear accidents. In one of the few quantitative studies, Fuhrman (2012) found that major nuclear accidents slowed the construction of nuclear reactors in all regime types, but that democracies are more affected than authoritarian regimes. This dissertation considers the regime type to be important to the policy outcome, will clarify the relationship in later chapters.

- *Time Proximity Factor*: The more time that passes after a nuclear accident decreases the likelihood of policy change.

A nuclear disaster increases the public's attention to the need for nuclear policies and the timing of new policies is often tied to their proximity to an accident. Initial public responses to accidents are often more hostile, and as time passes, the concerns brought by the disaster fade. In past examples of nuclear accidents, there is often a swift policy response immediately following the accident, but support for the policy change dissipates and often reverses as time goes on. Sweden and Italy have both followed this pattern. After the Three Mile Island accident, Sweden voted in a national referendum to phase out nuclear power. By the 1990s the government then decided to continue to extend the life of existing plants and by the 2000s plans were in place to replace existing plants. Similarly, in Italy following Chernobyl a national referendum voted down nuclear power in the country, but by the late 2000s plans were in place for the expansion of nuclear sites. There is a timing factor in a nuclear accident driving policy change, which merits consideration in this dissertation related to Fukushima, especially if a state has a history of policy change after an accident.

- *Climate Change/Energy Security Factor*: Policy changes on nuclear energy are associated with concerns about climate change and national energy security.

Before Fukushima, nuclear power was seen as a solution to issues stemming from climate change and energy security problems. Nuclear power emits fewer greenhouse gases than the alternatives (natural gas and coal) and many countries can secure a domestic supply. In February 2010, U.S. President Barack Obama said, "to meet our growing energy needs and prevent the worst consequences of climate change, we'll need to increase our supply of nuclear power. It's that simple."[28] Teräväinen, Lehtonen, and Martiskainen (2011) found in three country case studies that "nuclear power is portrayed as a solution to the problems of climate change and energy security, while the traditional concerns for accident and radiation risks – and, to a certain extent, nuclear waste management – have been pushed to the background" (3441).

Political Scientists have long debated nuclear security which is typically defined as the availability of adequate energy supplies at reasonable prices (Deese 1979/80, 140). Threats to energy security can leave states strategically vulnerable, and thus there is a need to find other sources of energy that do not expose vulnerabilities. Likewise, climate change increasingly leaves states vulnerable and this vulnerability encourages the promotion of cleaner energy alternatives. Nuclear energy is often touted as a solution. As Glaser (2012) states "nuclear power is time-tested and

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[28] Remarks by the President on Energy in Lanham, Maryland, February 16, 2010.

scalable; its life-cycle carbon-emissions are about 10 to 20 times below those of coal; and many countries consider access to uranium more robust than access to other resources so that nuclear power would promise greater energy security" (27). Despite this, even though nuclear power does not emit CO2 when producing electricity, research has found that climate change concerns have only had limited impact on acceptance of nuclear power plants (Corner et al., 2011 and Visschers et al., 2011). Despite there being a limited finding of the actual impact of climate change and energy security concerns, it remains an argument that adversaries and proponents of nuclear power use in their framing of policy options.

- *Economic Alternative Factor*: The high price of nuclear energy, especially after an accident, can instead promote alternative energy solutions, and less investment or interest in nuclear power.

The economic incentives (or disincentives) for nuclear energy have factored into policy decisions. Even though over the long term nuclear energy is cheaper and more stable than its alternatives, its start-up capital costs are expensive. And with the huge economic investment it can be easier for utilities and energy planners to find alternative energy sources. Prior to Fukushima, long-term natural-gas prices and price forecasts more than halved in the United States, and electricity demand dropped on average owing to the economic slowdown (Bradford 2012), worsening the odds for nuclear. Nuclear accidents only exacerbate and impose further economic costs, which can halt development. As Bradford (2012) contends, "accidents at nuclear plants and economic changes have occurred before, within the living memory of global financial communities. The knowledge that any of these events — or new future threats — might happen has long discouraged investors” (151).

For example, at the height of the nuclear renaissance, it seemed that nuclear power was charged to make a comeback. Between 2006 and 2009, the U.S. Nuclear Regulatory Commission received 18 applications for combined construction and operations licenses (COLs) for new nuclear reactors. At this time, the demand for energy was on the increase and as such, the price for nuclear power on a large scale was competitive, so utilities initiated plans for building new nuclear power plants. Beginning in 2009, however, the price of natural gas fell dramatically and following this it became more difficult for nuclear power to be economically competitive as a source of energy generation. To date, the Nuclear Regulatory Commission approved only 5 of the COL applications for new nuclear power stations (the rest were either withdrawn or suspended). Only two have actually begun construction (at Vogtle in Georgia and V.C. Summer in South Carolina). It seems unlikely that any more plants will begin construction while the price of natural gas remains low, especially after heightened regulatory changes were initiated following the Fukushima accident.

- *Technological Development Factor*: Technological developments in nuclear reactors provide an incentive for states, especially small ones, to keep or consider nuclear energy as a viable option.

Many contend that even before Fukushima the prospects for nuclear energy were fading. Already under pressure from its lack of economic viability, nuclear power in the post-Fukushima era has faced increased regulations and costs. Kessides

(2012) contends that "for nuclear power to play a major role in meeting the future global energy needs and mitigating the threat of climate change, the hazards of another Fukushima and the construction delays and costs escalation that have plagued the industry will have to be substantially reduced" (8). New developments in reactor technology may serve as a way forward as states consider nuclear energy policies. Most of the nuclear reactor technology in use today is built using designs from half a century ago, and there has been little adaptation of new technology since. Some contend that change in nuclear energy policy is motivated by changes in technology that can make the benefits of nuclear power more appealing.

For example, recently, a promising direction for nuclear development is the movement to downsize from large scale reactors to less complex and more affordable units. In particular, much attention has been given to small modular reactors (SMRs), as they could become a more desirable nuclear power possibility because of their lower capital requirements, small size, ability to "build as you go" and scale to demand need, and suitability for small electric grids. The small grids in particular may be especially appealing to developing countries in the future. According to Kessides (2012), SMRs "are scalable nuclear power plant designs that promise to reduce investment risks through incremental capacity expansion; become more standardized and reduce costs through accelerated learning effects; and address concerns about catastrophic events, since they contain substantially smaller radioactive inventory" (9). Even more appealing, most of the current SMR designs include passive safety features that make a meltdown or Fukushima type accident nearly impossible.[29] In considering

[29] For example, NuScale's Power Module design uses natural circulation to provide coolant flow (not via coolant pumps, the bane of Fukushima's meltdown) and can safely shutdown and cool itself indefinitely in the event of offsite loss of power.

the implications of Fukushima, “it is useful to consider the burgeoning development of small nuclear reactor (SMR) technologies as a notable example of the guidance that technological innovation and development provide towards a clearer way forward after this incident” (Hubbard 2014, 98).

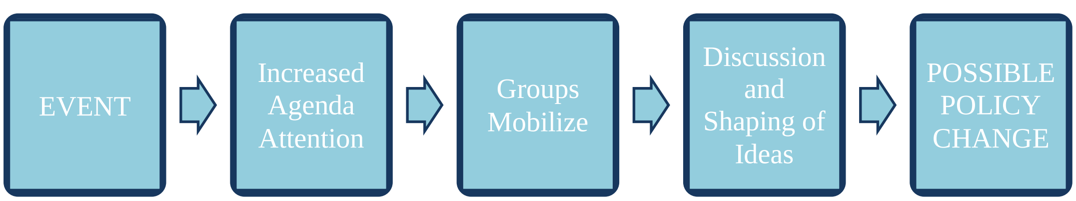
2.5.2 *Rationalist Decision Making in Nuclear Policy*.

In looking the different factors that drive policy changes on nuclear energy, much of the underlying logic stems from rationalist explanations. However, these explanations do not address the socially constructed factors that capture the motivation to change nuclear policy, especially after an event like Fukushima. Although no two groups or organizations arrive at decisions in the same way, the process usually involves the consideration of three issues: the situation, the objectives, and the consequences of alternatives (Tuler 1995). Traditionally, rational-choice models prevail on nuclear decision making. They rest on the assumption that actors have complete information, that an existing utility function defines preferences, and that an accepted decision rule is in place (March 1981). This notion “assumes that external conditions dictate choice and that the details of an organizational structure or decision-making process do not affect final choices” (Tuler 1995, 271). Tuler further explains that most members of organizations do not behave consistently with that model particularly in nuclear accidents because of incomplete information about choices, alternatives, and consequences is not available; and not all members of an organization have the same goals, and goals change over time. He says, for example, that “organizations often experience conflict and ambiguous preferences, ignore information they possess, request more information and then ignore it, and buffer processes of thought from processes of action" (Tuler 1995, 272). With nuclear accidents, stakeholders find it challenging to determine the reliability of what the situation is in the first place, their objectives, and what possible consequences might arise since the understandings of the situation varies greatly. A further difficulty stems from the fact that the decision-making process does not take place within the same organization, but is diffused across multiple players. Therefore, purely rationalist explanations of nuclear policy choice are insufficient and there is a need to incorporate better constructed understandings of how the nuclear agenda and decision-making gets framed.

2.6 Theoretical Contribution

In contrast to the factors discussed above, I propose an alternative theoretical explanation to account for policy change following a nuclear accident. I want to follow the vein of Birkland (2006) to examine actual policy change after disaster, not just agenda change. As such, I propose the following model for how a nuclear disaster functions as a potential focusing event that can change policy.

Figure 2.1: Focusing Event Progression



In the model above, the event (nuclear disaster) is the impetus for increasing the attention of a given issue (national nuclear energy policy) gains, which then mobilizes and renews the vigor of various actors that have a stake in the process (policy entrepreneurs, interest groups, regulatory officials) who then discuss and promote ideas (reduce or continue national nuclear energy advances) that can bring policy change. It is important to note that not all ideas are going to lead to change, but the event creates the environment necessary for change.

2.6.1 *Focusing Events*.

One of the key questions this dissertation project grapples with is how and why certain policy decisions are reached after a given disaster. Focusing events are the mechanism through which these questions are examined. Birkland (1997) notes that "focusing events provide an opportunity for advocacy in the guise of analysis, but have substantial benefits for advocates of policy change. Focusing events are unplanned and unpredictable, and unpredictable events force all sides of a policy controversy to respond to a perception of a policy failure, or at least a severe problem with existing policy, at the same time" (133)

It is important to note that focusing events do not always necessarily lead to policy change, but they often pave the path. According to Kingdon (2011), focusing events "rarely carry a subject to the policy agenda prominence by themselves. They need to be accompanied by something else… they reinforce some preexisting perception of a problem, focus attention on a problem" (98). Focusing events are not always important, nor are they the sole trigger of attention to the problem. Kingdon adopts a very broad definition of focusing events which can include events, crises and symbols. A focusing event can help open a window of opportunity since it highlights the policy failure with a “bowling over” effect (Kingdon 2003) Kingdon has stated that a focusing event was a “little push” “like a crisis or disaster that comes along to call attention to the problem, a powerful symbol that catches on, or the personal experience of a policy maker” (Kingdon 2003, 94–95).

Focusing events get so much attention because they provide evidence of policy failure. Policy failures come in multiple forms: they can fail to meet goals, cost more than planned, or create unintended consequences. And with failure, there is hope for improvement and learning. The identification of an event’s failures brings a desire to change. As Birkland (1997) explains, “focusing events can work as a catalyst for policy change by serving as signals of policy failures and opportunities for participants in policy making to “learn.” This learning is facilitated by the opportunities for policy advocacy afforded by a focusing event” (131). But when looking at a nuclear focusing event, the concept of learning may not be particularly helpful. For example, “in the United States, the accident at Three Mile Island brought public opposition to a peak. TMI effectively foreclosed firm political leadership for the nuclear option and cemented the tendency toward decentralized control in nuclear policy” (Joppke 1992, 131).

With increased attention comes public engagement, but sometimes it lacks staying power as the memory of the event fades. In another example, the Chernobyl disaster immediately provoked strong negative emotions, but eventually saw a “recovery of public confidence after about a year… In the UK only 41 per cent of the population supported the nuclear program immediately after Chernobyl; eighteen months later the figure had risen to 56 per cent. Out of sight, out of mind, applies to nuclear energy as to much else" (Price 1990, 285). Nuclear accidents thus do not always stick as a lesson to learn from (Nohrstedt 2008). The efficacy of the focusing event and the potential for change is largely seized by how the agenda is framed.

2.6.2 *Social Construction.*

Many scholars recognize that the way a problem is defined and framed will ultimately determine which problems garner consideration and which do not.[30] "The process of defining problems and of selling a broad population on this definition is called social construction. Social construction refers to the ways in which we as a society and the various contending interests within it structure and tell the stories about how problems come to be the way they are." (Birkland 2006, 122) The initial framing of any such event typically reflects political conflict and divergent understandings of causation. In framing of the event causal stories assign blame, identify victims, legitimize certain actors as "fixers" and creates new political alliances (Stone 2002, 209). Furthermore, as Deborah Stone argues:

> In politics, causal theories are neither right nor wrong, nor are they mutually exclusive. They are ideas about causation, and policy politics involves strategically portraying issues so that they fit one casual idea or another. The different sides in an issue act as if they are trying to find the "true" cause, but they are always struggling to influence which idea is selected to guide policy. Political conflicts over causal stories are therefore more than empirical claims about sequence of events. They are fights about the possibility of control and the assignment of responsibility (2002, 197).

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[30] See Kingdon (2003), Cohen, March, and Olsen (1972), and Jones (2001).

This social construction of reality following a nuclear accident will be explored in the "micro" case studies later in this dissertation. Specifically, these cases will describe the construction is of the Fukushima event and how its construction shapes public interests and ultimately policy agendas.

2.6.3 *Expectations.*

From this general model, I derive several specific expectations about focusing events that apply in this case with Fukushima:

- *Most if not all actors have an interest in learning from the focusing event, but how much they learn and whether that ushers actual change varies.*

Focusing events promote efforts to learn. As a base supposition, it is assumed that all actors involved in the stakes have an interest in learning. No legitimate actor in any policy domain wants to see a nuclear meltdown in their own country, and thus wants to do what is possible to prevent such an outcome. But the policy instruments through which problems will be prevented or mitigated will differ from participant to participant in the policy process because the depiction of *how* problems come to be and therefore how they are solved, will be different depending on each participant's ideological and organizational commitments.

- *Group mobilization is linked in time to a particular focusing event.*

A focusing event brings the potential to mobilize groups, at specific points in time. It takes an event to motivate group mobilization. Countries with national nuclear energy programs have established antinuclear groups, but often these groups do not achieve much movement until an incident happens. As was the case with the US antinuclear movement and Three Mile Island, there was an antinuclear movement "with environmental groups, antinuclear public-interest groups, and local antinuclear and intervenor groups pressing their case against nuclear power," and yet they really only got fuel from the TMI accident (Birkland 1997, 117). Specific incidents help groups to mobilize, and the mobilization is tied to that one incident. The mobilization is limited in its effect to the time around the focusing event.

- *The increase in group mobilization will be accompanied by an increase in the discussion of policy ideas.*

As more actors are heard and engaged in the process, more policy ideas will proliferate. The emphasis focuses on the ideas as solutions themselves, which is in line with a more refined view of policy making. "Policy scholars and political scientists have tended to view participation in policymaking and politics as a process in which power is wielded to promote an individual's or group's interest. Since the 1980s this primarily interest-driven notion of politics has given way to a more subtle understanding of politics and policymaking." (Birkland 2006, 8)

- *There is a relationship between ideas and policy change.*

Change becomes more likely when ideas gain prominence after events. The literature suggests that new ideas are not developed in response to an event. Instead, focusing events tend to reinvigorate attention to preexisting ideas. “An important element of politics, and agenda setting particularly, is the importance of symbols and stories in the framing of public issues. The symbols and stories are framed by participants in policy making ad propagated by the mass communications media.” (Birkland 1997, 12) Furthermore, the construction of ideas is a key indicator as to how policy will change. Social construction of the event is important to Birkland (1997) when understanding which proposed solutions reach the agenda and with what effect as “it seems clear that the identification of accidents—how harmful, how important, or even whether an accident occurred at all—is largely a process of social construction, not simply empirical observation and measurement” (121). This construction plays beyond the event to provoke ideas about the event. As Kingdon (1995) argues with his “streams metaphor” of agenda setting and alternative selection, one has to look at the substantive meaning of *ideas* in the policy process, and on the ability of actors in the policy process to prevail in competition over ideas.

- *Policy change and learning is not always automatic.*

Just because mobilization occurs and new ideas are generated, policy change or learning is not guaranteed. A lack of policy change can happen for a number of reasons and some actors will not learn from the problem. It is often assumed that policy change equates to learning (Hoberg 1996, Birkland 2006) but this is often misunderstood. Learning can occur without policy change, and learning can also accumulate over time (between focusing events).

- *Learning can decay over time.*

While learning may accumulate from one event to another (and be helpful the next time a focusing event happens), knowledge can also be forgotten as time passes. The intervening time between focusing events can cause policymakers to forget what they've learned, even if interest groups do not. According to Birkland (1997, 1998, 2006) there is little research on taking a long duration approach and comparing the time spent between events and what happens to learning in the intervening periods. Birkland admittedly has not focused on this work himself, but suspects that it is a fruitful avenue of research and it can help uncover how focusing events change the saliency of issues for places in time.

2.7 Overall Assessment and Gaps in the Literature.

This research examines the extent to which nuclear disasters function as a global focusing event, bringing increased agenda attention that provokes group mobilization and brings a reevaluation of ideas. This all leads to the potential for policy change in the aftermath of the event, even in countries that the disaster does not physically touch. In doing so, it undertakes questions of how various actors come together during a nuclear disaster to perceive risk, engage and construct a dialogue, and mobilize over time. To date, no major comparative studies about the far ranging implications of nuclear disasters as focusing events has been undertaken (Chien 2013, Aoki and Rothwell 2013). Furthermore, the link between focusing events and policy change is not well established (‘t Hart & Boin, 2001, Birkland 1997, 2006). It is especially important to the field of disaster studies that this gap be filled, as it can provide insight into why certain events gain prominence and how cycles of learning and policy change play out over the long haul. This project attempts to rectify both of those weaknesses.

Asking questions of nuclear policy choice and change after disaster necessitates many different literatures that do not fall neatly under one field of study. In all, there are many considerations to make on the assessment of the existing literature. Out of the various areas, a few places of weakness emerge, and this dissertation hopes to help to fill in several specific gaps in the various literatures it addresses comparative investigation across countries of the impacts of a nuclear accident, adds more constructivist accounts that include social factors instead of favoring rationalist approaches, assesses varying risk perception across different countries, the nature of policy change across time, and how and way focusing events become important.

2.7.1 *Comparative Investigation*

A noted weakness of the disaster literature is that it relies upon single case study investigation of problems (Aldrich 2008). The strength of this research is that a comparative context will be given to the problem. With nuclear accidents in particular, Chien (2013) says that “most existing studies focus on explaining the link between crisis and reform in a single country” (118). For example, the Three Mile Island disaster is one of the most comprehensively investigated accidents in industrial history; but, few studies have been examined for results in the comparative context and only look at it as a policy event in isolated examples. By not exploring the comparative context of policy change, we are missing out on crucial aspects of how policy learning occurs. With the comparative basis, we can ask how states look at a disaster that occurred elsewhere and in turn, make effective policy change. Chien (2013) has encouraged this kind of comparative work, saying that "although it is difficult to establish causal links between crises and the lack of reform due to non-falsifiability, the research value of this line of inquiry should not be ignored… By examining the impact of a crisis on several polities, the variations in empirical findings may yield new insights in further theory building" (120). Following the incidence of Fukushima specifically, there have been few scholastic examples that examine the impacts of the disaster on changes in policy across comparative examples.

2.7.2 *Against Rationalist Explanations*

Among the competing explanations of nuclear choice, most stem from rationalist accounts. These explanations rely upon physical, structural, or economic factors. What is often overlooked are socially constructed factors that play out in a post-disaster context. To that sense, this dissertation illuminates the other elements that require upon constructivist explanations. Through both quantitative and qualitative examination, there is ample room to explore the existing explanations for nuclear policy change after a disaster. In this dissertation specifically, the contending "factors" will be explored through quantitative evaluation to see how well the explanations hold up in the post-Fukushima context.

2.7.3 *Risk Perception Across Varying Polities*

There are a few issues with existing conceptions of risk perception that this dissertation hopes to elucidate. According to Yamamura (2013) "the issue of the relationship between the subjective risk of a nuclear accident and experiencing natural and technological disasters appears to remain open to discussion [and] it is worth exploring the relationship between them" (360). The perceptions of citizens' regarding risk do have an influence on policy concerning disasters (Viscusi and Zeckhauser, 2006 and Kahn, 2007). I explore how the perception of risk has an effect on policy change. There is not one singular narrative or perception of risk from nuclear energy that emerges from the disaster. Instead, countries have understood and framed risk in their own way in light of the singular, factual event. At present, the literature does not explore how risk (especially involving nuclear energy) is perceived in other contexts.

2.7.4 *Movements For Change Over Time*

The existing literature on nuclear policy after a disaster does not take into consideration policy changes across time or how the drive for change varies dramatically across time. "Longitudinal studies are scarce in the field of risk perception and acceptance of technologies. As a result, it remains unknown how stable people's attitudes towards technologies are, and how strongly they are influenced by technological accidents." (Siegrist and Visschers 2013, 116) Mostly, studies only consider the policy options during a limited amount of time. For example, there were many immediate policy changes after the Chernobyl accident (Sweden and Italy quickly passed policies against nuclear energy) but the lasting impact of the movement for change lacked staying power (and both countries' policies were under revision just before the Fukushima accident). This research hopes to look across time at how states and actors involved in the policy process interact within a greater movement following disaster. As Joppke (1992) points out, "most previous studies looked at states as passive "opportunity structures" for collective mobilization, not as actors involved in behavioral exchanges with movements" (2). Additionally, this study aims to analyze movement trajectories over time and the phase of movement decline. Previous studies of nuclear accidents do not consider the effects across time as movement strength wanes and some states make reversals from their past policy decisions.

2.7.5 *How and why focusing events are important*

Focusing events are often cited as important, but there is little research on how and why these events are important. This study will examine those questions in depth. According to Birkland (1997, 2006) there is much need to investigate focusing events in domains where very few potential focusing events have occurred before, and the nuclear energy realm is one such domain with few potential events, but often a large chance of turning into an actual focusing event.

2.8 In Conclusion

Within the field of political science, there is a lack of recent interest and expansion of nuclear energy research questions, especially since many casusal observers have considered the prospects for new nuclear power in the US as nonexistent since the Three Mile Island Accident. However, the extended future for nuclear power is promising, and momentum is starting to build within the industry. Both the short term possibilities from SMR and Gen VI reactors and longer term potential from non-lightwater "advanced" reactors may bring a revitalization of the nuclear industry. As such, there is still much work to be done in studying nuclear energy. This dissertation brings questions about nuclear power development to political science, and bridges its study and application with insights from disaster studies and public policy. This research project proposes that nuclear disasters function as a global focusing event, bringing increased agenda attention that provokes group mobilization and brings a reevaluation of ideas, all leading to the potential for policy change in the aftermath of the event even in countries that the disaster does not physically touch. A primary purpose of this dissertation research is to advance our understanding of policy change stemming from technological disasters through agenda setting behavior which can be understood from socially constituted approaches.

There is a great deal of literature about nuclear disasters, but as a whole the field struggles to overcome problems of complexity and comparability. Because of the highly specialized and technological nature of nuclear power plant design, nuclear disasters are complex phenomena that are not entirely well understood. Information on radioactive particles, decay rates, and detection is well grasped by scientists, but how radiation interacts within elements of a complex environmental system is much more difficult to assess. Even more, it is not well understood how systems of risk management and perception can interact in addition to make issues more compounding and complicated. This system is often not well comprehended by policymakers, planners, and responders who interact in their own complex and entangled political system that is not well understood itself. And then when the interaction of the nontechnical general public is included, there are even more opportunities for misunderstandings.

When policy makers look at nuclear accidents in other states (as many countries did in response to the 2011 Fukushima disaster), information may be obscured or false (as it was at Fukushima during various instances TEPCO and the Japanese government purposely withheld or even falsified information). Furthermore, it is even more problematic to make effective policy decisions on national nuclear energy programs following an accident when the scope of the damage potential may be unclear, as it was after Fukushima.[31] And yet, nuclear accidents have far reaching consequences, even for places that do not directly experience the actual fallout. As is the case in many places following Fukushima, political and policy fallout swayed national nuclear choices. The many contributions that this dissertation makes are crucial to understanding state policy change and nuclear energy decision making.

2.8.1 *Nuclear Renaissance?*

Taking up the nuclear option has wavered over time in its popularity and practicality in various places. At the start civil nuclear programs were achieved by states with nuclear defense development, and quickly spread to many places[32] through the 1960s and 1970s with support from the U.S.[33], the Soviet Union, and occasionally

[31] As of March 2017, TEPCO had only recently gotten the first look at the melted down cores of the damaged reactors, but still lacked sufficient information about the extent of the damage and many unknowns remain unanswered.

[32] Not just to major sources of developed nuclear ambitions (such as the "big power" US, USSR, UK, France, etc), but also to many developing countries like Brazil, Argentina, South Africa, Mexico and South Korea.

[33] This support perhaps came with rather dubious intentions. According to Elliot (2012), "The US was energetic in promoting [nuclear] technology under the 'atoms for peace' banner, but some saw this as a part of an attempt to consolidate or expand its technological, political and economic hegemony." (2)

Canada and the U.K. But as time went on, major accidents (at Three Mile Island, Pennsylvania in 1979 and Chernobyl, Ukraine in 1986), the extra cost of heightened safety regulations, the expense nuclear energy compared to other energy options (especially in light of the falling price of fossil fuel), the problems of waste and weapons proliferation concerns, and the added weight of public opposition from environmental and other advocacy groups considerably slowed the implementation of nuclear energy around the world.

However, by the 1990s and 2000s, another shift occurred and countries observed increased talk of a “nuclear renaissance”[34]. This was born as nuclear energy was reimagined under the banner of a low carbon energy choice that could help fight off climate change and was led forward by emerging big energy consumers like China and India (Findlay 2010). Expansion was further on the mind, as Elliot (2012) claims, “in the early 2010s, some EU countries were reversing their opposition to nuclear, Russia was expanding its programme and the US was looking to a new programme,” in addition to places like Chile, Venezuela, Egypt, Saudi Arabia, Kuwait, Jordan and the UAE. But, by 2011 the risks of nuclear programs were brought to the forefront when the safety and health issues of the Fukushima disaster cast new doubts over the worldwide future of nuclear energy.

Has Fukushima brought an end to this nuclear renaissance? Or, did the disaster not substantively change prospects for nuclear energy around the world? Can we observe a widespread worldwide response to Fukushima?

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[34] For an overview of the term nuclear renaissance, see Nuttal (2005). For pre-Fukushima assessments of nuclear renaissance, see Ahearne (2011) and Goodfellow et al. (2011).

So far, the reaction to Fukushima is mixed. According to many accounts, “the public reaction to Fukushima worldwide has made the development of nuclear power more difficult” (Zaleski 2013, 261). And yet, even if many would have liked Fukushima to mark the end of the nuclear era, the reality may be otherwise, as others claim, “it is almost impossible to totally exclude nuclear power from the future energy mix, even if hydrocarbons may one day be totally supplanted, which, for the foreseeable future, remains a yet unfulfilled dream” (Basrur et al. 2012, 196). For many states, nuclear cannot be ruled out, especially in a global energy outlook that is still heavily dependent on baseload electricity generation. Even the surge of new renewables over the last decade still pose an unfulfilled promise as they are plagued by issues of intermittency and efficiency. Nuclear still retains certain advantages in the energy market today.

In most respects, the global nuclear renaissance has tempered following Fukushima. The post-Fukushima trend towards nuclear energy is perhaps best captured by a statement made at the end of September 2011 by Jukka Laaksonen, Finland’s senior nuclear regulator: “As a general observation, I would state that after the first shock the reactions of the general public Fukushima accident have been very moderate. With the exception of Germany, the impact to the existing nuclear programs seems to be most moderate” (Zaleski 2013, 261). Most assessments of post-Fukushima nuclear policy prospects have a garnered only modest takeaways, even though the public perception of nuclear energy has declined rather dramatically. Some country-level projections for new nuclear energy have come to a grinding halt. For example, in the United States, two new Westinghosue AP1000 projects were licensed and approved for construction in 2008, in addition to a host of other imitation projects popped up in the following years. However, out of the dozen or so applications received, only the two new projects have proceeded. The others have been subject to budget increases, construction delays, and increased scrutiny. Following Fukushima, the pace for nuclear had moderated.

In summary, the literature reviewed above contributes to our understanding of nuclear accidents and policy change. Previous accounts of the factors that enable policy change on nuclear energy following an accident are given, and I propose an alternative explanation that relies on an understanding of event change from focusing events. The previous theoretical explanations combined with the focusing event account will guide the quantitative and qualitative considerations in the next chapters of this dissertation. Specifically, the quantitative work will examine the previous factors to see how well they hold up following the Fukushima disaster, and my proposed alternative framework will be extrapolated across three country case studies. In totality, the work considered has exposed a gap in scholarship where this study can situate nicely and advance understanding of policy change and the impacts of nuclear accidents.

Chapter 3

QUANTITATIVE RESEARCH DESIGN

As George and Bennett (2005, 74) point out "the formulation of the research objective is the most important decision in designing research." My dissertation studies why a focusing event like Fukushima provokes policy change in some cases but not others through a mixed methods approach employing quantitative comparative analysis and case studies. This mixed methods approach provides a holistic and comprehensive understanding of the dynamics of policy change. This dissertation relies on the current literature and multiple cases in order to provide a "chain of evidence" (Yin 1981) which in turn allow for "thick descriptions" (Geertz 1973) that explain why comparable cases chose divergent policy paths. This dissertation draws upon comparative politics, but its analytic framework is also contextualized through public policy by exploring the degree to which Fukushima exhibited a focusing event policy window opening. Comparative analysis allows scholars to explain the variation across cases by illuminating broader patterns of factors, outcomes, and policies that would not be visible from a study of a single case (Garrett and Moore 2010). The literature on disaster events often falls into the trap of relying only on single cases within a singular disaster instead of comparative approaches or looking at multiple cases even in a single event. Dynes (1989, 2005) repeatedly warned the field of disaster studies about the danger of extrapolating from single cases of disasters and has advocated for cross-national and comparative research to improve the generalizability of conclusions and the accuracy of arguments. With Fukushima, this dissertation studies the national context and compares its influence in other national contexts. This strategy accounts for additional variation from the multiple countries' reactions to the Fukushima disaster. Furthermore, with the inclusion of the numerous independent variables, this project gains a benefit of being able to evaluate many factors at once, and holds a comparative control over all of the cases relative to the qualitative case studies. The use of current literature, data, and case studies is also beneficial in that these methods may provide lessons to direct future disaster policy.

This dissertation employs a mixed methods approach. Both quantitative and qualitative analyses will be used to answer the research question. The chapter will assess the impact of the Fukushima disaster on nuclear energy policy change by using quantitative indicators. There will be a subsequent section that will take account of the more unquantifiable factors of interest through qualitative case studies. From the example of Fukushima, a case of policy retraction, a case of policy status quo, and a case of policy advancement will be process traced individually and then put up for comparative examination to determine (1) how alternate pathways of nuclear policy developed and (2) what rich description of an individual case can establish. Establishing causal stories is important in both agenda setting and in laying the groundwork for the selection of alternative policy directions (Stone 1989). The qualitative methodology and design will be described in further detail in a later chapter. For now, this chapter is focused on the quantitative exploration of the research question.

The quantitative goal of this chapter is to better understand the quantitatively causal directions and motivations of policy change in nuclear energy policy after the Fukushima accident. This presents a number of methodological concerns, in particular a small number of cases, limitations of data reliability and measurement, and possible alternative explanations. For these and many other reasons, a qualitative consideration is necessary. However, the question of Fukushima and policy change must also include quantitative factors: unique stories of individual cases can be told, but there is a larger, broad scale comparative story to be told across the international level about what can be said about countries' choices on nuclear energy in the aftermath of a major accident. This quantitative account is key to establishing a baseline of comparison across actors and identifying what indicators have commonality and an established correlation. The inclusion of a large number of independent variables and control measures across the cases allows for a comparison and big picture analysis not readily available in previously existing scholarship. Added variation from the independent variables and resulting analysis is a contribution this project can make. Although much of the quantitative indicators are far from definitively conclusive, patterns of the likelihood of policy choice can emerge and contribute to our understanding of which factors are most important.

3.1 Hypotheses

Existing theoretical explanations for what accounts for policy change decisions on national nuclear energy following an accident have identified several factors: distance, public opinion, regime, climate change and energy security, economic success, elections, and power. While there is individual evidence to support each claim, such arguments have not been quantitatively evaluated in concert together. One of the goals of this research is to uncover the merits of what previous scholarship has indicated as well as see how past insights hold when evaluated together and across a wide range of countries.

- **Hypothesis 1:** States closer in geographic proximity to the Fukushima accident site will be more likely to adopt anti-nuclear policy changes.
- **Hypothesis 2:** States that are more preoccupied with concerns about climate change will be more likely to adopt pro-nuclear policy changes.
- **Hypothesis 3:** States that are doing well economically will be more likely to adopt pro-nuclear policy changes.
- **Hypothesis 4:** States that are more powerful and resource-plenty will be more likely to undertake pro-nuclear policy changes.
- **Hypothesis 5:** States that demonstrate sway from public opinion will be less likely to undergo pro-nuclear policy changes.
- **Hypothesis 6:** States that have a high level of energy insecurity will be more likely to adopt pro-nuclear policy changes.
- **Hypothesis 7:** States that have had an executive or legislative election within a year after Fukushima will be more be likely to adopt anti-nuclear policy changes.
- **Hypothesis 8:** States that are democratic are more likely to adopt policy changes against nuclear energy.

This research project investigates each factor and draws an expected increase or decrease on the likelihood of policy change either for or against nuclear energy.

Table 3.1: Hypotheses Expectations

With an increase in:	**Likelihood of Pro-Nuclear Change**	**Likelihood of Anti-Nuclear Change**
Geographic Distance	Increase	Decrease
Climate Change	Increase	Decrease
Economic Success	Increase	Decrease
Power	Increase	Decrease
Public Opinion	Decrease	Increase
Energy Security	Decrease	Increase
Elections	Decrease	Increase
Democratic	Decrease	Increase

It is anticipated that political factors like public opinion, elections, democracy, and energy security (a politicized concept) will increase the likelihood against nuclear energy. With this, the logic underlying is that politics are accountable to public and respond to changes in the public opinion. Likewise, with more structural variables where there is little to or no input from political dynamics, such as economic success, geography, power, and climate change concerns, there is an expectation of states having greater inclination towards pro-nuclear positions. A summary of all the hypotheses will be given, and then from there each individual hypothesis will be addressed with statistical summaries and then later will be examined in the broader context with a larger model.

Table 3.2: Summary of All Hypotheses

Factor			
Power Factor	**National Capabilities ↑:** (Composite Indicator of National Capabilities (CINC) score) *Likelihood of nuclear commitment ↑* *Likelihood of nuclear abandonment ↓*	**Military GDP ↑:** (Military $ as % of GDP) *Likelihood of nuclear commitment ↑* *Likelihood of nuclear abandonment ↓*	
Economic Success Factor	**GDP Growth Rate ↑:** (GDP growth %) *Likelihood of pro change ↑* *Likelihood of anti change ↓*		
Public Opinion Factor	**Media freedom ↑:** (World Press Freedom Index) *Likelihood of pro change ↓* *Likelihood of anti change ↑* *Likelihood of nuclear abandonment ↑* *Likelihood of nuclear commitment ↓*	**Interaction of Media Freedom and Population ↑:** *Likelihood of policy change backwards ↑* *Likelihood of policy change forwards ↑*	
Regime Type Factor	**Regime type ↑:** (Polity IV) *Likelihood of pro change ↓* *Likelihood of anti change↑*	**Democracy ↑:** (Freedom House Index) *Likelihood of pro change ↓* *Likelihood of anti change↑*	**Freedom ↓:** (Freedom House Index) *Likelihood of pro change ↓* *Likelihood of anti change↑*
Geographic Proximity Factor	**Distance from Fukushima ↑:** (Minimum geographic distance) *Likelihood of policy change ↓*		
Climate Change/ Energy Security Factor	**CO2 Emissions ↑** (Carbon dioxide output) *Likelihood of pro change ↑* *Likelihood of antichange ↓*	**Energy Security ↓:** (Net energy imports) *Likelihood of pro change ↑* *Likelihood of antichange ↓*	**Nuclear Share ↑:** (% electricity from nuclear generation) *Likelihood of pro change ↑* *Likelihood of antichange ↓*
Elections Factor	**Executive Elections ↑:** (Within one year of Fukushima) *Likelihood of nuclear commitment ↓* *Likelihood of nuclear abandonment ↑*	**Legislative Elections ↑:** (Within one year of Fukushima) *Likelihood of nuclear commitment ↓* *Likelihood of nuclear abandonment ↑*	

3.2 Case Selection

The individual unit of analysis in this quantitative section is the country, and 49 countries are included in the analysis. The outcomes correspond to societal and national-level policy and opinion responses to the disaster, and as such the country is a natural fit for the unit of analysis. Furthermore, many of the independent variables proposed in the hypotheses in the preceding chapter are country- or society-level factors. A country-year approach was not the most useful given the lack of variability it provides. In attempting to identify the policy change of a given country, sufficient time must be given for an outcome to develop, and to this end the temporal domain of the cases are years subsequent to Fukushima. For policy change variables specifically, the year prior to the accident is considered the base from where "change" is measured, and 2014 (three years after Fukushima) is the endpoint at which the policy change is determined. If a country-year analysis had been undertaken, it would have obscured the potential policy change and bury it. Instead, a larger unit of time is used in this analysis on whether change happened or not, and it is not preoccupied with identifying when it happened. The lag in policy adoption means that looking at countries' outcomes across a number of years post-Fukushima is more sensible than just looking at a country year or two. Not all cases would adopt policy change at the same time nor is this project concerned with how quickly a case adopted policy change after the accident, so looking at the units in a standardized time frame (measured from the year prior to Fukushima to three years after it) provides a basis for the variable of interest: policy change. I note that available data of countries post-Fukushima is relatively sparse, temporally speaking, which means that there is not a lot of variation to disaggregate.

These countries were selected due to their inclusion in the Country Nuclear Power Profiles (CNPPS) database that is maintained by the International Atomic Energy Agency (IAEA). A total of 51 countries total are included in the IAEA CNPPS database,[35] including the 30 countries that have operating nuclear power plants, as

[35] The Country Nuclear Power Profiles (CNPP) compiles background information on the status and development of nuclear power programs in Member States. The CNPP is updated based on information voluntarily provided by the respective national of

well as the 21 countries with past or planned nuclear power programs (two countries, Japan and Syria, are dropped from my analysis, as explained below). These countries have the strongest ties to the development of nuclear energy capability based on their past, present, or future potential. They encompass a diversity of polities from around the globe, from the highly developed and democratic to the developing and autocratic, which allows for a rich and comparable analysis of states that is not just concentrated on one region or type of regime or capability. Furthermore, the cases chosen ensure sufficient variation of the independent variables of interest. The states in the CNPPS also represent diverse experiences with nuclear energy capabilities, but at different levels ranging from highly developed to decommissioned entirely to highly exploring nuclear potential (which itself demonstrates varying commitment to nuclear energy). The countries thus examined in this quantitative exploration are:

Table 3.3: Countries Included

Argentina	Canada	Germany	Jordan	Netherlands	Slovakia	Tunisia
Armenia	Chile	Ghana	Kazakhstan	Nigeria	Slovenia	Turkey
Bangladesh	China	Hungry	(Rep.) Korea	Pakistan	South Africa	Ukraine
Belarus	Czech Rep.	India	Kuwait	Philippines	Spain	UAE
Belgium	Egypt	Indonesia	Lithuania	Poland	Sweden	United Kingdom
Brazil	Finland	Iran	Mexico	Romania	Switzerland	United States
Bulgaria	France	Italy	Morocco	Russia	Thailand	Vietnam

These 49 countries provide the best lens through which to observe the varying factors of influence on policy change. Data is used from the most recent years

participating IAEA Member States and contains information officially provided by authorities. The CNPP's main objectives are to consolidate information about the nuclear power infrastructures in participating countries, and to present factors related to the effective planning, decision making and implementation of nuclear power programs that together lead to safe and economical operations of nuclear power plants available[36] with the exception of the policy change considerations, which look at the timeframe from a year before the accident to three years subsequent. One would not want to include the entire population of countries for evaluation because such an endeavor would be futile if a country had no serious interest or sustained capability in developing nuclear energy (as the majority of the 196 countries of the world today do not).[37] I only study the countries that do have this previous experience or current promise for nuclear energy. Even though using such a small sample of countries brings small n issues to the study (discussed in more depth later), expanding the cases beyond these relevant examples would lose the application of change in the nuclear energy arena. If we consider countries where no change would happen because of no serious vestment into nuclear energy, then it would be incredibly difficult to identify or measure the relevancy of policy change when it does come to light because of it is obscuring by too many other countries that have no share into the outcome. Therefore, the sample is limited by these factors; I only consider the countries that have demonstrated a nuclear energy past, present, or future ambitions.

Although 51 countries total are considered by the IAEA as significant because of their past, present, or future activity on nuclear energy, this dissertation will only use 49 of these countries. As mentioned previously, two countries (Japan and Syria)

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36 In most cases, this is 2014 and 2015. Full details and deviations from this are found in the codebook, see appendix 1.

37 Including irrelevant cases that would never opt for nuclear energy would attenuate my findings (i.e., bias findings for all variable effects towards zero), as there would be countries that are effectively impervious to any external shock (such as Fukushima). There is a similar rational often offered for studying only "relevant dyads" (contiguous countries or pairs of states involving at least one major power) within quantitative analyses of war and militarized interstate disputes (MIDS).

were excluded due to problematic outlier issues. Syria was problematic on the account of missing data. Since 2011 (the starting year this dissertation project is interested in, the year of the Fukushima accident) Syria has been entrenched in a brutal civil war that has left almost no area of its political system, economy, or capabilities sector untouched. Thus, almost all data related to the nuclear industry were either unavailable, unfurnished, or unreliable. Even estimates of base indicators were unavailable from essential sources[38] because of the widespread impacts of the civil war. It would not be expected that Syria would have any reasonable capacity for decision making on a nuclear sector. Therefore, Syria was dropped from considerations because it is not able to contribute much to the study in the way of actual data. Secondly, the case of Japan was difficult to include with all the other cases because it has its own unique experience with nuclear in light of being the location where the accident occurred. The shadow of the accident created a unique policy context among cases given that it was the site of the accident, and the direct impact of the accident has made for a different policy making context than other countries. It defies categorization on outcome because it was neither committed to nuclear or abandoning nuclear—it has been, and remains to be, in an undecided holding pattern on nuclear energy. Even though Japan has recently restarted some of its nuclear reactors after shutting them all down after the Fukushima accident, the impacts and implications of such an action are far from conclusive. There are many who would like, and are lobbying extremely hard, to shut down nuclear power in Japan forever. At the same time, there are many others who acknowledge that it will be very difficult for

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[38] Like the CIA World Fact Book or UN reporting data

Japan to move forward with any energy future without nuclear power.[39] Thus, the inclusion of Japan into the data creates another outlier situation because of the indeterminate ability to properly categorize it at this juncture. Furthermore, when considering the robustness of the dataset, preliminary checks and models were run on the data that included the case of Japan and the ensuing results were not stable. In these instances, Japan perfectly predicted the model and prevented any kind of meaningful interpretation from the rest of the cases. For these two reasons, not including Japan among the countries considered maintains the robustness of the cases considered.

3.3 Data

The data gathered on these countries come from a variety of open source material. Whenever possible, data were chosen on the basis of usage and acceptability in political science research from widely cited sources. Country control data were largely obtained through government provided composites including the CIA World Fact Book,[40] the UN,[41] and the World Bank.[42] Content specific data, when possible, came from respected and well used in political science sources like the Freedom

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39 Indeed, an entire dissertation could be written on the nuclear policy choice of Japan in the aftermath of the Fukushima accident. Such an extensive discussion is outside the scope of this project.

40 https://www.cia.gov/library/publications/the-world-factbook/

41 http://data.un.org/CountryProfile.aspx

42 http://data.worldbank.org/

House Index,[43] Polity IV,[44] and CINC from the Correlates of War project.[45] Nuclear data was obtained through sources like the IAEA "red book" or other agency sources, the Nuclear Energy Institute, and OECD data.[46] Data that was coded by hand was reflected by parameters established in the codebook (see appendix) but drawn from country reported information to the CNPPs database.

The variables are chosen to suit the purpose of this dissertation. The question this dissertation seeks to answer relates to the position states take on nuclear energy following the Fukushima accident. The dependent variable of consideration is a state's post-Fukushima stance on nuclear energy. To consider the question, this dependent variable can be broken down in two ways: 1) by addressing which direction policy change took place and 2) a policy spectrum of outcomes.

To measure policy change, I consider a binary selection of whether or not change occurred. In addition, when change did occur, I use the following binary metrics: whether or not there was change that was pronuclear energy (binary), whether there was or was not change that was antinuclear (binary), and whether there was a continuance of the status quo and no change on the standing of nuclear energy (binary). The choice to use a binary dependent variable was considered initially in comparison to multinomial logit or ordered prohibit approaches. By using a binary

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43 https://freedomhouse.org/report/freedom-world/freedom-world-2016

44 http://www.systemicpeace.org/polity/polity4.htm

45 http://cow.dss.ucdavis.edu/data-sets/national-material-capabilities/national-material-capabilities-v4-0

46 http://www.oecd-nea.org/ndd/pubs/2014/7209-uranium-2014.pdf

variable, the primary emphasis is placed on change, and not what the outcome of that change was. The binary approach allows analysis of change (be it antinuclear or pronuclear) to be primary. A dependent variable that is based on ordered numbers or categories can obscure the results. Furthermore, the analysis as policy change is not necessarily an ordered or linear comparable constant. As such, using a counts approach is not the most sensible decision. By looking at the direction of policy change, the impacts of on the covariants of policy change on nuclear energy will be best assessed.

Furthermore, the commitment of the policy standing on nuclear energy after the accident is used to understand where states standing in their nuclear policy, beyond that policy being a change from any previous stance. Rather than just exploring the direction of policy change, this variable captures the varying stances that states could assume on nuclear policy following the Fukushima accident. This variable is captured separately from the binary variable on policy change in order to ensure that analysis of the independent variables can be considered in conjunction with how committed a state is to a given policy (as opposed to whether that policy changed in the aftermath of the Fukushima disaster). As described in the table below, the response variables were coded from qualitative information in the IAEA “red book” and CNPPs database.

Table 3.4: Dependent Variables

VARIABLE	DEFINITION	DESCRIPTION
POLICY CHANGE ON NUCLEAR VARIABLES		
Policy Change (Anti-Nuclear) Binary	0-No Policy Change 1-Policy Change	Binary variable for change of policy that is anti-nuclear energy following the Fukushima accident (change defined as actual/passed policy decision at the national executive (including regulatory agencies) or legislative level that shifts away from pre-Fukushima nuclear energy standing. Change is indicated by decline in new nuclear energy plants, policies aimed at reduction of nuclear power energy output, plan and/or shutdown of existing reactors)
Policy Change (Pro-Nuclear) Binary	0-No Policy Change 1-Policy Change	Binary variable for change of policy that is more staunchly pro-nuclear energy following the Fukushima accident (change defined as actual/passed policy decision at the national executive (including regulatory agencies) or legislative level that expands from pre-Fukushima nuclear energy standing. Change is indicated by increase in new nuclear energy plants, policies aimed at expansion of nuclear power energy output, plan and/or increased capacity or lifetime of existing reactors)
No Change (Status Quo) Binary	0-Policy Change 1-No Policy Change	Binary variable for continuance of pre-Fukushima nuclear policy stance.
CURRENT STANDING ON NUCLEAR VARIABLES		
Abandon Nuclear	1	Countries with nuclear power industries in which anti-nuclear sentiment is longstanding, and in which the Fukushima incident was the catalyst for decisions to abandon plans for new reactors, and/or force the closure of existing plants
Abandon Nuclear Now	2	Countries with existing nuclear power phaseout policy, but now subject to additional social and/or political pressure to accelerate their phaseout planning
Nuclear for Now	3	Countries without existing nuclear power plants, but with plans to build a nuclear power industry which they plan to either continue
Committed to Nuclear	4	Countries with mature nuclear power industries which appear ready to continue to develop them despite any adverse reactions by their people as a result of Fukushima

Table 3.5: Summary Statistics for Dependent Variables

	No Change	Anti-Nuclear Change	Pro-Nuclear Change
# of Countries	26	10	13
Countries	*United Kingdom, United States, Ukraine, Tunisia, Spain, South Africa, Slovenia, Slovakia, Romania, Pakistan, Nigeria, Morocco, Mexico, Jordan, Iran, Indonesia, India, Ghana, France, Finland, Czech Republic, Canada, Bulgaria, Brazil, Belarus, Argentina*	*Thailand, Switzerland, Sweden, Netherlands, Kuwait, Italy, Germany, Egypt, Chile, Belgium*	*Vietnam, United Arab Emirates, Turkey, Russia, Poland, Philippines, Lithuania, South Korea, Kazakhstan, Hungry, China, Bangladesh, Armenia*

	Firmly Committed to Nuclear	Nuclear for Now	Abandon Nuclear for Now	Abandon Nuclear Completely
# of Countries	9	30	7	3
Countries	*United Arab Emirates, United States, United Kingdom, Russia, South Korea, India, France, Canada, China*	*Vietnam, Ukraine, Turkey, Tunisia, South Africa, Slovenia, Slovakia, Romania, Poland, Philippines, Pakistan, Nigeria, Netherlands, Morocco, Mexico, Lithuania, Kazakhstan, Jordan, Iran, Indonesia, Ghana, Hungary, Finland, Czech Republic, Bulgaria, Brazil, Belarus, Bangladesh, Armenia, Argentina*	*Belgium, Chile, Egypt, Kuwait, Thailand, Sweden, Spain,*	*Switzerland, Germany, Italy*

The independent variables of interest are brought together to assess a number of different explanations. Primarily, they are used to address the hypotheses of prevailing explanations of nuclear energy policy choice while also providing for new avenues of question with indicators of the nuclear market. Together, they will be able to provide and hold constant many different indicators of the commonly held explanations of policy change on nuclear policy overviewed in the previous chapter. The following quantitative evaluation explores the different factors that have been given in previous research to see how well they uphold following the Fukushima case. In short, the previous explanations of nuclear policy change consider factors such as geographic proximity, public opinion, regime type, climate change/energy security, economic alternatives, and technological development. These factors are the building blocks of the hypotheses of this dissertation, given at the beginning of this chapter. The independent variables included in the dataset are used operationalize the various factors.

Table 3.6: Independent Variables

VARIABLE NAME	DEFINITION	SOURCE
Democracy Binary	0-Non-Democracy 1-Democracy	Freedom House Index
Regime Type	-10 to 10 scale of regime authority (autocracies to democracies)	Polity IV data
Freedom	1-7 scale of freedom (7 being the worst)	Freedom House Index
Media Freedom	0-100 index score (the lower the score, the better freedom)	Reporters Without Borders
Population	# (log)	CIA World Factbook
Area	# square kilometeres	CIA World Factbook
Distance	# miles in straight line from Fukushima to closest country border	Google earth
NPT ratification	0-No ratification 1-Yes ratification	NPT Signatory data
GDP	$ amount (log)	CIA World Factbook
Economic Growth Rate	% growth rate of GDP	World Bank
CO2 emissions	CO2 emissions in thousand metric tons	UN data
Kyoto Protocol	0-No agreement 1-Signatory	Kyoto Signatory data
Human Development Index	1-Very high (above .790) 2-High (.700-.790) 3-Medium (.550-.699) 4-Low (below .550)	UN data
National Material Capabilities	Composite Indicator of National Capability (CINC score) ranging from .000000 to .198578	Correlates of War data
Military Expenditures Total	Military expenditures $USD in millions in 2014	
Military Expenditures %	% of military expenditure as a share of GDP	Stockholm International Peace Research Institute
Nuclear Weapons	0-No nuclear weapons 1-Possesses nuclear weapons	Federation of American Scientists
Nuclear Supplier Group	0-No membership in Nuclear Suppliers Group 1-Membership in Nuclear Suppliers Group	NSG data
Energy Security	% energy imported	World Bank
Renewable Energy Generation	Total Renewable Electricity Net Generation (Billion Kilowatthours)	US Energy Information Administration
Market for Renewables?	% energy use from renewables and nuclear (from total energy used)	World Bank

Nuclear Operating Pre	0-No current nuclear energy production 1-Yes current nuclear energy production	IAEA PRIS
Nuclear Operating Post	0-No current nuclear energy production 1-Yes current nuclear energy production	IAEA
Power by Nuclear Energy	% electricity generated by nuclear	IAEA
GW.h Nuclear production	# GW.h production of electricity by nuclear power (net)	IAEA
Nuclear Generation Capacity	GWe net generation capacity of nuclear energy	OECD, NEA, and IAEA "Red Book"
Nuclear Plans Pre	# Power plants with firm plans pre-Fukushima	IAEA CNPP 2010
Nuclear Plans Post	# Power plans with firm plans post-Fukushima	IAEA CNPP 2015
Nuclear Construction Pre	# Power plants under construction pre-Fukushima	Nuclear Energy Institute, World Watch
Nuclear Construction Post	# Power plants under construction post-Fukushima	Nuclear Energy Institute
# Operation Pre	# reactors in operation pre-Fukushima in 31 Dec 2010	IAEA
# Operation Post	# reactors in operation post-Fukushima in 2015	IAEA
Nuclear Generation Pre	Total amount of electricity in millions of killowat hours in 2010	UN data
Nuclear Generation Post	Total amount of electricity in millions of killowat hours in 2012	UN data
Legislative Elections	0-No elections 1-Yes elections	Country Level data
Executive Election	0-No elections 1-Yes elections	Country Level data
Uranium employment	# persons in Uranium production employment per year	OECD, NEA, and IAEA "Red Book"
Uranium market	$ cost of domestic uranium exploration (in thousands of USD)	OECD, NEA, and IAEA "Red Book"
Uranium Production	Production of uranium in metric ton in a given year	UN data
Uranium resources	National uranium supply in tons.	OECD, NEA, and IAEA "Red Book"
Nuclear Trade Agency	0-No Nuclear Trade Agency 1-Existence of a National Nuclear Trade Agency	IAEA and Country Level Data
Uranium Requirements	Requirement uranium in tU to operate reactors as of Jan 1 2013	IAEA Red Book
Electricity Generated	Electricity generated at nuclear power plants in TWh net	IAEA Red Book

Previous undertaking on the subject of this dissertation have been limited, and have not attempted such a broad comparison between many country cases. Studies that do investigate the question of policy change after Fukushima tend to do so with only a handful of examples compared together; and do not consider all of the cases that have a serious past, present or future nuclear association—closer to a population of relevant nuclear cases. In the examples that only study a few cases, typically only a few cultivated variables are of interest whereas this study will systematically consider many possible factors together that influence policy. In relation to the number of influential features under study here, there are real diversity of factors, from economic to nuclear to political, that this project leverages. This provides more holistic accounting of possible. Finally, these variables are important for their consideration not just for policy change, but also policy standing.

3.4 Small N Considerations

Given the number of cases available, at 49 countries and cross sectional observations, the small sample size brings concerns about the ability of my quantitative research design to sufficiently distinguish between the multiple competing claims and explanations. With small N studies, case selection is important, because it makes a great difference as to whether or not the outcomes are the same in each case. Because of the pressure to bracket the variables, it is vital to include all possible variables—even though it may not yield a clean result and increases the chance of an erroneous conclusion. For this project, the expansion of the cases is not a worthwhile venture. To do so would obscure the actual interest of this project, which are states that already have a vested interest in nuclear energy—as we try to understand what happens with that interest. Therefore, only the cases that have a strong past, present, or future involvement into national nuclear energy are countries that are considered.

Given the limitations of the small N issues present in the cases available for study in this area, Lieberson's (1991) framework of probabilistic outcomes is a useful perspective for understanding the methodological approach. He distinguishes between casual propositions that are deterministic and probabilistic. On the one hand, deterministic claims hold that a given factor will lead to a specific outcome. While on the other hand, probabilistic claims are more modest, and a given factor will merely lead to an increase in the likelihood of an outcome. But taking into account the limitations and necessity of the cases chosen for study, a probabilistic model is the best available. Because “we do not know or cannot measure all the factors that we think will influence Y. As a consequence, we are again obliged to relinquish a deterministic *measurement* of the influence of X on Y, even if we are prepared to make a deterministic statement about its influence.” (Lieberson 1991, 309) In modeling the data, it is expected to be able to make definitive claims about the nature of the relationships found that offer predictability. Despite the challenges of doing so, small N studies still operate by deterministic principles and avoid probabilistic claims even if those are better suited. For many reasons this deterministic tactic is not suitable for the claims of the case studies evaluated here, even though the predictability standard is largely expected.

For example, when looking at the incidence of nuclear accidents, the probabilistic rather than deterministic approach is indispensable in looking at the general historical context. In the major instances of nuclear accidents, there is a usually a reactive pushback against nuclear energy in the aftermath that wanes as time passes after the event. The data in this study cannot capture this historical timed factor, but it may be an important overall causal variable. Therefore, calculations about one event may be inconclusive when not taken into a larger context.

Because we cannot account for all factors across time from the small sample, a probabilistic approach is necessary to evaluate the existing evidence. In taking up the empirical consequences of a probabilistic stance, issues of indeterminancy will be present. But, in doing so, this outlook will accept that it can make claims about an outcome without giving it the final authority of the matter. As Lieberson (1991) says in relation to errors with small N outcomes: “The existence of a measurement error means that a given data set may deviate somewhat from a hypothesized pattern without invalidating the hypothesis.” (309)

3.5 Model Choice.

The goal of comparison is to provide a contextual description of the political phenomena we observe, classification for the purposes of classification, hypothesis testing that provides explanations, and finally to predict patterns of observable behavior (Landman 2000). Both qualitative and quantitative research designs can achieve these goals if executed properly. Qualitative analyses commonly employ a small-N, comparing few countries or single country studies, while quantitative statistical methods are more used with large-N to compare many countries. Generally there is a trade-off in scope between the two approaches, which facilitates establishing inferences about causal relationships and predicting future outcomes vs. abstraction, as we examine each observation with less detail. Case-oriented methods are classic comparative methods. They are oriented toward a comprehensive examination of historically defined cases and phenomena. And, they emerge clearly from one of the central goals of comparative social science: to explain and interpret the diverse experiences of societies, nations, cultures, and the like. The variable-oriented approach is less concerned with understanding specific outcomes or categories of outcomes and rather more concerned with assessing between relationships discernible across many societies or countries.

For the sake of this project, both types of understanding will be necessary to fully understand the problem. This research is interested in both the large scale picture that we are able to gather (from the variable orientation) and in the enriched detail of the unquantifiable factors from contextualized places (in the case studies). In the realm of comparative research, increased emphasis has been given to mixed method bridging approaches that can take the best of both worlds. As Collier, Seawright, and Brady (2003) note on the value of bridging methods: “The different components of qualitative and quantitative methods provide distinct forms of analytic leverage, and when they are combined in creative ways, innovative research can result.” (7) The authors advocate for emerging overlap between the former staunch divisions of qualitative and quantitative divide, and encourage ways for the techniques of both approaches to be applied to the other. Even with the disadvantages of a small sample size, there is still value added from what we can gather from the data available.

This dissertation employs a few different statistical methods to look at the available universe of cases. In the ensuing chapter, I apply statistical techniques to analyze the cases discussed above. In these respects, while the small sample size and temporal bounds limit my abilities to apply a number of more advanced statistical methods, my approach and research design do nevertheless provide a reasonable basis for the use of logistic (i.e., logit) regression analyses. With binary variables, a logit model is the most commonly used choice to model potential relationships. Such a model choice can estimate the probability of a discrete outcome, either terms of percent change or odds ratios, which is appropriate given the interest in determining policy change.

Included in the next chapter are summary tables and comparison tables that give insight into what single factor evidence can exist. I will explore pair-wise correlations that evaluate the potential bivariate relationships between the dependent variable and each of my independent variables. With an intermediate to small size sample of countries to draw from, utilizing a full blown regression model with all parameters would be reckless due to the potential for the corresponding high levels of multicollinearity to increase my standard errors and the potential for type II errors. But, at the least, an attempt at establishing quantitative models can still provide some insight. In spite of some of the potential modeling challenges, this dissertation will use logistic regression, with an expectation of the results taking a probabilistic understanding.[47] I built 6 logits models to account for specific factors as outlined below, on each outcome dependent variable on policy change:

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47 A standard logistic regression with standard errors was employed. Other types of logit models were considered, such as standard probit and the Firth logit (which can be helpful when looking at rare events and small N sized data because it can produce finite, consistent estimates of regression parameters) but were ultimately deemed not the most appropriate model choice due to the sample size and parameters of this data. Firth logit methods in particular were not used because of the emphasis on rare events. Although a nuclear disaster such as Fukushima is considered a rare event, the data as used in this project do not reflect a rare event outlook as the dependent variable is not a nuclear accident (rare event) but policy change (which is not a rare event). Utilizing a firth logit would not be the most effective choice and it would overestimate the condition of interest.

Table 3.7: Model Descriptors

	Name	Variables
Model 1	Economic success	GDP, GDP growth rate, population, CINC, HDI, Electricity Generated
Model 2	Political factors	Population, HDI, executive elections, legislative elections, regime type, democracy, media freedom, military expenditure
Model 3	Structural factors	GDP, population, CINC, HDI, democracy, nuclear generation capacity, area, distance.
Model 4	Energy factors	CINC, nuclear generation capacity, CO2 emissions, energy security, nuclear generation, market for renewables, uranium production, nuclear share
Model 5	Mix Combination 1	GDP, electricity generated, democracy, CO2 emissions, energy security, media freedom, military expenditures total, nuclear share, number of plants operating post
Model 6	Mix Combination 2	GDP, GDP growth rate, HDI, executive elections, legislative elections, democracy, CO2 emissions, nuclear share, distance, military expenditures as a share of GDP.

These models are grouped around specific variables because of the hypotheses they are trying to answer, in addition to including other variables for control measures. For example, the model on political factors looks at isolating the hypotheses that gives political factors, such regime type or the impact of elections. The models include two mixed with a combination of variables. These mixed combinations are included to provide models that include a wider variety of inputs and how they might interact in a less contained model. Will the control be maintained when other variables are included within the same model? The variables chosen in the mixed combination were selected to draw parts from the other model and include them together. While none of the models will be definitive in their conclusions, they will still be able to lend probabilistic claims and allow us to examine our hypothesized relationships across a vast number of countries before investigating the case studies for thicker description. The next chapter will include the quantitative data analysis, with summary, hypotheses, and models.

Chapter 4

QUANTITATIVE DATA ANALYSIS

When studying policy change quantitative investigation is particularly helpful because it disaggregates the dependent variable that is of interest and interpret the independent effects of various controls. This study is interested a wide range of factors, be they political, geographic, economic, or otherwise, and as such the inclusion of a variety of independent variables can contribute to a wide analysis of many inputs. From conducting quantitative study, we can thus identify patterns in political processes across countries and regions, or even across the globe. While there is a tradeoff from the rich, thick description of qualitative investigation that can probe deeply into a question providing great depth, there is a value to consideration that cuts only to essential thresholds and questions through quantitative methods. This chapter will establish the quantitative indicators of policy standing after the Fukushima nuclear accident by providing the broadest level of examination on a global scale of correlated probabilistic relationships.

Why look at the research question quantitatively and what can be gained from this approach? The goal here is multifold. First, a quantitative approach builds upon existing research. Previous research on this topic is limited in temporal scope, data, and range of cases considered, and this quantitative investigation hopes to improve upon those deficiencies. As described in the literature review, existing research fails to explain policy change following the aftermath of the Fukushima disaster by using a wide scope of countries, many different indicators, and a timeframe that enables enough of a lag for policy change to develop. Second, by using data driven insights, this project establishes equivalency between cases. By studying each country case using the same set of parameters prior to undertaking the qualitative case studies, we better understand the larger systemic factors at work. Third, the quantitative analysis allows for a review of additional factors or explanations. I note that there are limitations to what such an analysis can provide. For example, the quantitative variables do not account for social factors such as advocacy group participation that can influence policy change. As such, the qualitative considerations explored in future chapters gain provide insight where the quantitative investigation may prove insufficient.

The chapter will proceed as follows: I explore the hypotheses presented in the last chapter individually in the bivariate context using pairwise correlations and other statistical inference, and then proceed to re-evaluate these hypotheses one by one in a multivariate context using logistic regression. I then analyze the policy change impact of Fukushima.

4.1 Section I: Bivariate Analysis

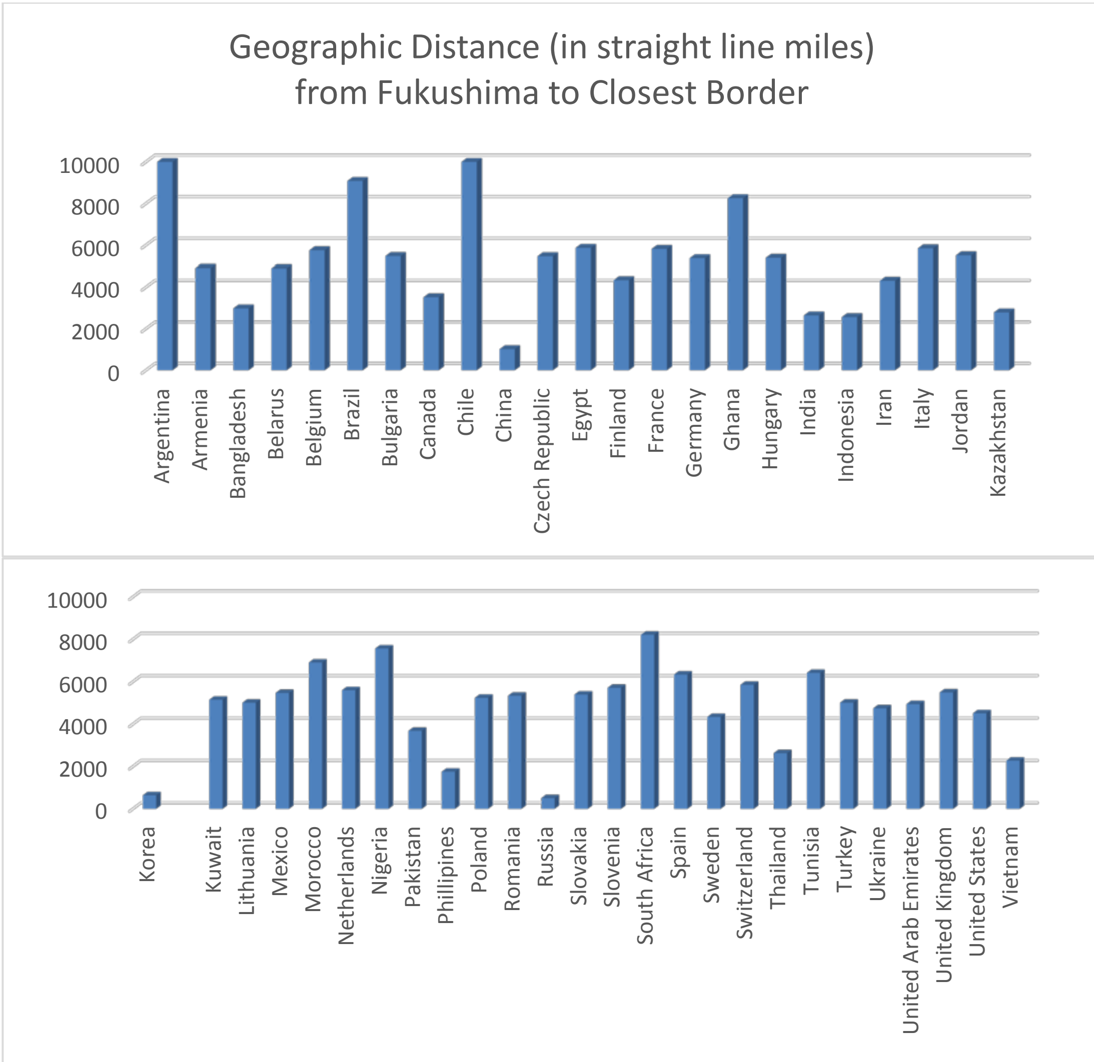
4.1.1 *Hypothesis 1: States closer in geographic proximity to the Fukushima accident site will be more likely to adopt an anti-nuclear policy change.*

Table 4.1: Geographic Distance Hypothesis

	Variable	**Likelihood pro change**	**Likelihood anti change**	**Measure**
Geographic Proximity Factor	*Fukushima Distance* ↑	↓	↑	Point-to-Point google earth distance

Geographic proximity to the site of the nuclear accident may play impact a country's perception of the fear of radiation and associated fallout damage. Countries with borders that lie closer to the site of the accident may be more likely to adopt policies against nuclear energy as they are more likely to come into contact with radiation (though this proximity factor is often misunderstood because of jet streams, prevailing wind patterns, and other environmental related factors not well understood by a general audience). This variable was created using mapping tools from GoogleEarth to chart the distance from the Fukushima nuclear reactor site to the closest political border of a given country. The distances were taken point-to-point in straight line miles. The distribution of this variable, across the countries in my sample, is plotted in the figure below in miles from Fukushima.

Figure 4.1: Geographic Proximity



In the aftermath of previous nuclear accidents like Chernobyl, where the accident created fallout across several countries, there perhaps a greater fear associated with the nuclear accident in Europe because it occurred so close to their "backyard." In these contexts, distance may have mattered greatly. Thus the hypothesis maintains that the closer to an accident the more likely that a stance against nuclear energy will be taken would generally hold.

Table 4.2: Correlation of Policy Change on Nuclear Energy and Distance

	Change Anti	Change Pro	No Change
Distance	0.1316	-0.5057**	0.3464*

*p<.05 **p<.01
Number of observations: 49

The expected relationship might not be as applicable in the Fukushima context. From a simple correlation of the distance from Fukushima and the policy change on nuclear power after the accident, the results indicate the opposite of what is expected. It is anticipated that as the distance from the Fukushima site increases, the likelihood of policy change in favor nuclear power would increase and the policy change against nuclear power would decrease. But as the correlation table shows, the farther from the Fukushima site you get, the likelihood of policy change against nuclear power increases and change in favor of nuclear power actually decreases. While this correlation is a simple measure, this distance factor, and its impact and potential alternative explanations, will be further explored when the model results are addressed as the results are likely more complex than indicated.

4.1.2 *Hypothesis 2: States that are more preoccupied with concerns about climate change will be more likely to adopt a pro-nuclear policy change.*

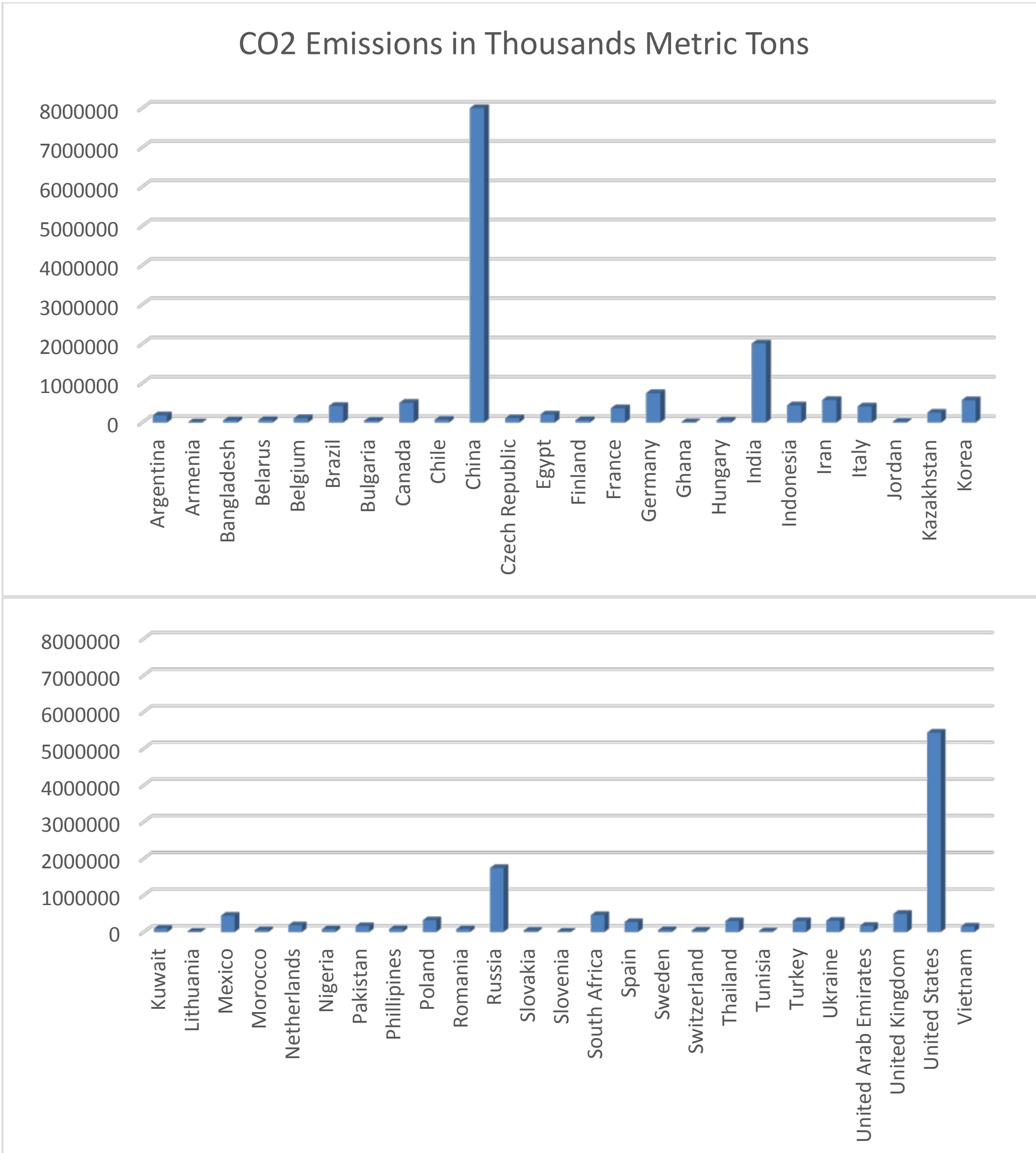
Table 4.3: Climate Change Hypothesis

	Variable	**Likelihood pro change**	**Likelihood anti change**	**Measure**
Climate Change Factor	*CO_2 Emissions* ↑	↑	↓	Carbon Dioxide output

Prior to Fukushima, during the emergence of the "nuclear renaissance," many accounts tried to explain for the renewed interest in nuclear energy, and among the most prominent drivers of change in developed countries came from the need to address growing worries about the potential negative effects of climate change (Helm 2007a). Even though there is much uncertainty about the effects of climate change and how they will impact specific countries (Parry et al 2007; Arnell 2004; Mendelsohn, Nordhaus and Shaw 1994), it could still be expected that the places that are most concerned about the potential damage and impacts of climate change will have greater incentive to implement low-carbon strategies like nuclear energy to prevent as much potential for catastrophe as possible.

In the next figure, the global distribution of carbon dioxide emissions is charted in thousands of metric tons across the selected case countries. China produces more CO_2 emissions than any country case, followed by the industrial power houses of the United States, Germany, Russia, and India. These countries would be most effective by the mounting concerns about the devastating impacts of climate change would be most relevant and by extension, would feel pressure to find energy alternatives.

Figure 4.2: Carbon Dioxide Emissions



Though previous nuclear disasters caused significant harm to the environment, the environmental movement itself is not unified on its stance on nuclear energy.

Some advocates argue that nuclear power is fundamental to combatting the potential of climate change, in spite of the Fukushima accident (Monbiot 2011, Lynas 2011, and Rosenbaum 2011). Nuclear proponents often cite the "cleanness" of nuclear energy when compared to other carbon intensive sources that heavily rely upon fossil fuels and argue that the quantities of energy nuclear power is able to provide may be one of the few ways to escape lasting climate change (Socolow and Glaser 2009, Lester and Rosner 2009, Lovelock 2006, Totty 2010, Edelstein 2009). Furthermore, in response to concerns about the safety of such production of energy, they cite the long standing successful industry record that has operated safely and without fatalities, which exceeds the operational records of the coal and oil industries (Monbiot 2011, Will 2010).

But even with this track record, nuclear energy faces increasing competition from renewable energy sources. The role that renewable energy generation plays in a state's power output may be related to a commitment to nuclear energy. If a state displays more interest in renewable energy, it may be likely to turn to nuclear power as an additional non-carbon power option. Alternatively, the more invested a state is in renewable energy, it may be more interested in developing those (solar, wind, hydro, etc) areas over than their nuclear capacity. The connection a state has from renewables to nuclear may indicate the energy policy pathways a state will find more attractive in the future.

Table 4.4: Correlation CO2 Emissions and Nuclear Policy Change

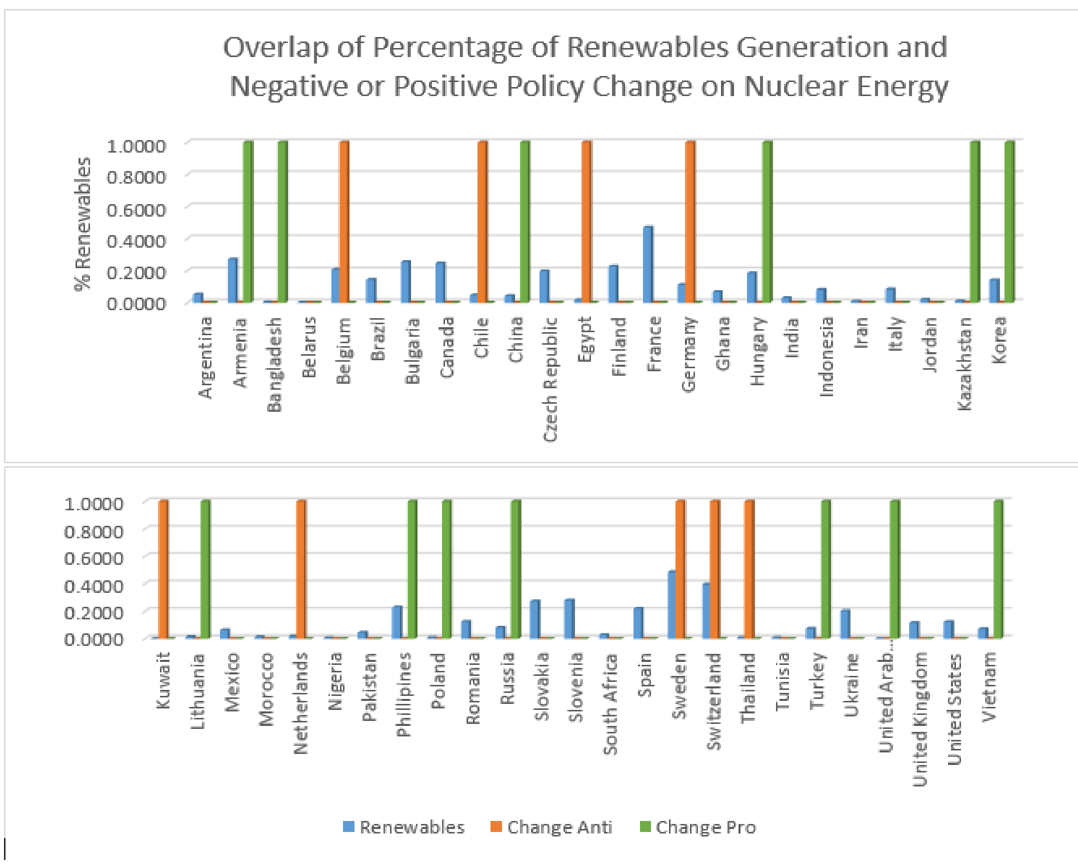
	Pro-Nuclear	Anti-Nuclear	No Change
CO2 Emissions	0.1624	-0.1191	-0.0514

*p<.05 **p<.01
Number of observations: 49

The figure below charts the overall percentage of energy generated from renewable energy in the selected countries. The chart overlaps countries that experienced pro-nuclear policy change after Fukushima (indicated by a green line) or anti-nuclear policy change (indicated by a red line).

Figure 4.3: Renewable Generation and Policy Change

Figure: Renewable Generation and Policy Change



From the figure, we see that a country's connection to renewable energy demonstrates a mixed bag of policy changes. Some countries with a high investment in renewable energy have decided to move away from nuclear energy such as Sweden, Belgium and Switzerland. Others like Kuwait, Thailand, and Chile that do not have high levels of renewable energy generation have moved away from nuclear energy. Countries that have more firmly moved toward expanding their nuclear policies are mixed between heavy investment and low investment in renewable energy.

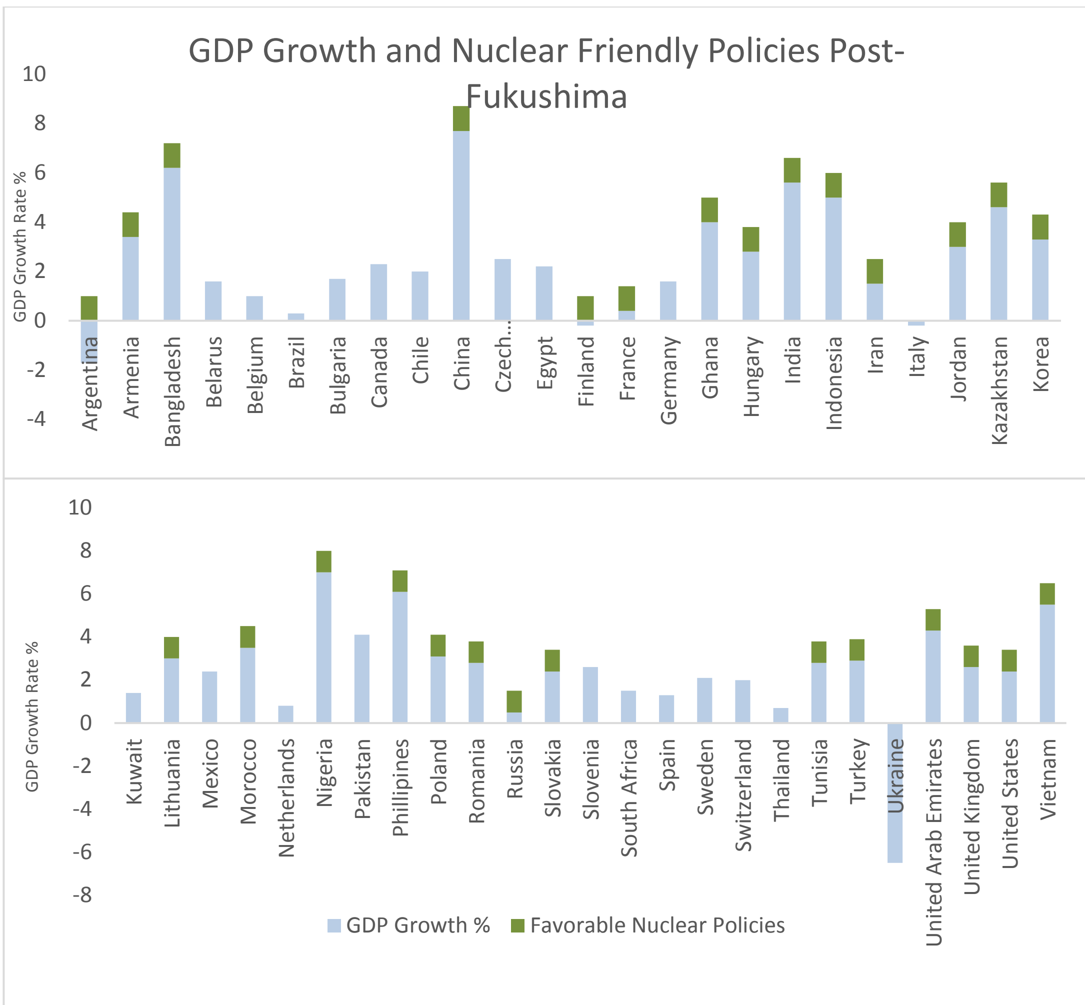
4.1.3 *Hypothesis 3: States that are doing well economically will be more likely to adopt a pro-nuclear policy change.*

Table 4.5: Economic Success Hypothesis

	Variable	**Likelihood pro change**	**Likelihood anti change**	**Measure**
Economic Success Factor	*GDP Growth* ↑	↑	↓	GDP Growth Rate %

Nuclear energy has incredibly high start-up cost, requires years of licensing, a highly capable technology sector, and most likely many sources of financing for a nuclear site and the very likely chance that it will run significantly over budget. Therefore, states that may not be doing well financially will see and feel the costs associated with nuclear energy more profoundly than a state that is experiencing a better economic condition. In a state experiencing economic growth, there are more avenues for investment and potential financiers to bring in money for nuclear projects. Inversely, in places where the financial aspects of nuclear energy are more constrained, an expected pull back from nuclear can be experienced because there may be a greater inducement to find cheaper alternative sources with financial constraints, we would expect to see less production of and investment in nuclear energy. Thus the hypothesis expects that states with a higher level of economic growth will be likely to actively expand their nuclear commitment, not just continue with previously friendly policies, and change policy to be more pronuclear.

Figure 4.4: Economic Growth and Nuclear Friendly Policies



The figure above charts the percentage of overall GDP growth in the selected countries and the green tips pictured overlap in countries that also experienced a pro-nuclear policy change after Fukushima. Following the hypothesis, countries that experience a higher level of GDP growth also tend to be more favorable to pro-nuclear policies. Almost all of the countries that experienced at least 3% GDP growth are favorable to nuclear power (with the exception of Pakistan). This implies that states experiencing significant growth are more likely to increase their nuclear capacity.

Table 4.6: Correlation GDP Growth and Nuclear Policy Change

	Pro-Nuclear	Anti-Nuclear	No Change
GDP Growth Rate	0.4468**	-0.1975	-0.2231

*p<.05 **p<.01
Number of observations: 49

Yet, as the above figure demonstrates, as GDP growth rate increases the likelihood of a pro-nuclear policy change also increases. Likewise, as a state's growth rate goes up, the likelihood that it will adopt antinuclear policies goes down. Rather surprisingly, however, is that as growth rate increases the likelihood of no change decreases faster than that of adopting antinuclear policy change. The fact that no policy change decreases slightly faster than antinuclear policy change suggests that perhaps the countries that did not change their nuclear energy policies in light of the Fukushima accident may be waiting for more favorable economic conditions before further developing nuclear power.

4.1.4 *Hypothesis 4:* States that are more powerful and resource-plenty will be more likely to undergo pro-nuclear policy change.

Table 4.7: Power Hypothesis

	Variable	Likelihood nuclear commitment	Likelihood nuclear abandonment	Measure
<u>Power Factor</u>	*National Capabilities* ↑	↑	↓	CINC Score
	Military GDP ↑	↑	↓	Military $ GDP

There may be a number of reasons as to why a resource rich country would develop nuclear energy capabilities. Firstly, a state with many resources may have the necessary infrastructure to create or maintain a nuclear program. Secondly, states may see a prestige factor associated with having the capability of technologically sophisticated energy production. Especially for countries lacking in other resources, establishing nuclear infrastructure further establishes prestige. Thirdly, states with a high proportion of military spending may be more pro-nuclear for both the potential security implications from nuclear energy and the energy security. Lastly, powerful states may already have a nuclear infrastructure established from nuclear weapons that allows for an easy cross-over to nuclear energy, giving them an incentive to continue with the resources already established.

Table 4.8: Correlation CINC Score and Nuclear Policy Change

	Pro-Nuclear	Anti-Nuclear	No Change
CINC Score	0.1360	-0.1325	-0.0176

*p<.05 **p<.01
Number of observations: 49

4.1.5 *Hypothesis 5: States that have more sway from public opinion will be less likely to experience pro-nuclear policy change.*

Table 4.9: Public Opinion Hypothesis

	Variable	Likelihood pro change	Likelihood anti change	Measure
	Media Freedom ↑	↓	↑	World Press Freedom Index
Public Opinion Factor	*Media Freedom & Population* ↑	↓	↑	World Press Freedom Index and interaction of Population Size

As described in chapter 2, scholars have extensively studied the impact of public opinion on nuclear energy (See Kim, Kim, and Kim 2013 for an overview related to how this is formed in response to nuclear accidents specifically). Siegrist and Viscchers (2013) found that attitudes about nuclear energy are relatively stable, though the accident at Fukushima had a moderate impact on opinion. Generally research focused on single or small country examinations of the role of public opinion plays in the development of the country's energy program. As literature has yet to explore these questions in the aggregate, I do so below. Not every country included in the sample has polling information available on the public's perception of nuclear energy. Furthermore, for a few countries, information may exist, but it is not from the same time period and thus obscuring the possibility for comparison.

Table 4.10: Correlation Media Freedom and Nuclear Policy Change

	Pro-Nuclear	Anti-Nuclear	No Change
Media Freedom	0.3201*	-0.2760*	-0.0693

*p<.05 **p<.01
Number of observations: 49

As an intermediary for public opinion, I use a measure of the freedom of the press. This measure can allows for observing several factors. It offers a perspective of the openness of the state by demonstrating that there are potential recourses for disagreement with the government. Additionally, it shows that there is the availability for many different kinds of information made available to the public. Exploring the interaction between media freedom and population shows the saliency of the size of the population to how open the information that they might receive is and if that can have weight in their political arena. A state that has a larger population can be expected to have a more robustly developed media and substantial resources that can be dedicated to policy prescriptions.

4.1.6 *Hypothesis 6: States that have a high level of energy (in)security will be more likely to adopt a pro-nuclear policy change.*

Table 4.11: Energy Security Hypothesis

	Variable	**Likelihood pro change**	**Likelihood anti change**	**Measure**
Energy Security Factor	*Energy Security* ↓	↑	↓	Net Energy imports
	Nuclear Share ↑	↑	↓	% electricity Nuclear

When states are unable to fully security their domestic energy supply, they may be attracted to nuclear power as a way to achieve energy independence or to diversify sources of energy supply (Yergin 2006, Helm 2002, Lidsky and Miller 2002). Many scholars have explored the energy implications for national defense, economic growth, and modern life in general (see Yergin 2006).A state is considered to be energy secure when there are adequate supplies of energy available for consumption at reasonable cost. Energy insecurity results when there is not enough energy supply domestically to meet demand, and foreign energy imports are necessary to continue to meet the gap.

Many states turn to nuclear energy to escape their energy insecurity. In the 1960s, Argentina underwent economic sacrifices to develop and build nuclear power reactors because concerns about dependence on foreign sources of energy made energy security a national priority (Poneman 1982, 129). In the 1970s, in large part because of the oil embargo of 1973, several countries like Japan and France significantly invested into increasing their nuclear energy infrastructure in no small part as a means of increasing national security.[48] More recently, in early 2009 when Russia threatened to cut off energy lines to the rest of Europe over disputes with the Ukraine, many states justified a renewed push in nuclear energy as a result of the national security interests at stake (Momigliano 2009, Eckert 2009). In looking at trends across time, Matthew Fuhrmann (2010) examined 1965-2002 and found that a heavy dependence on energy imports has been a fairly consistent factor in explaining why countries build nuclear reactors.

[48] The United States also explored expanding nuclear energy in the 1970s, though some of the enthusiasm was stymied for economic reasons as well as the Three Mile Island accident in 1979.

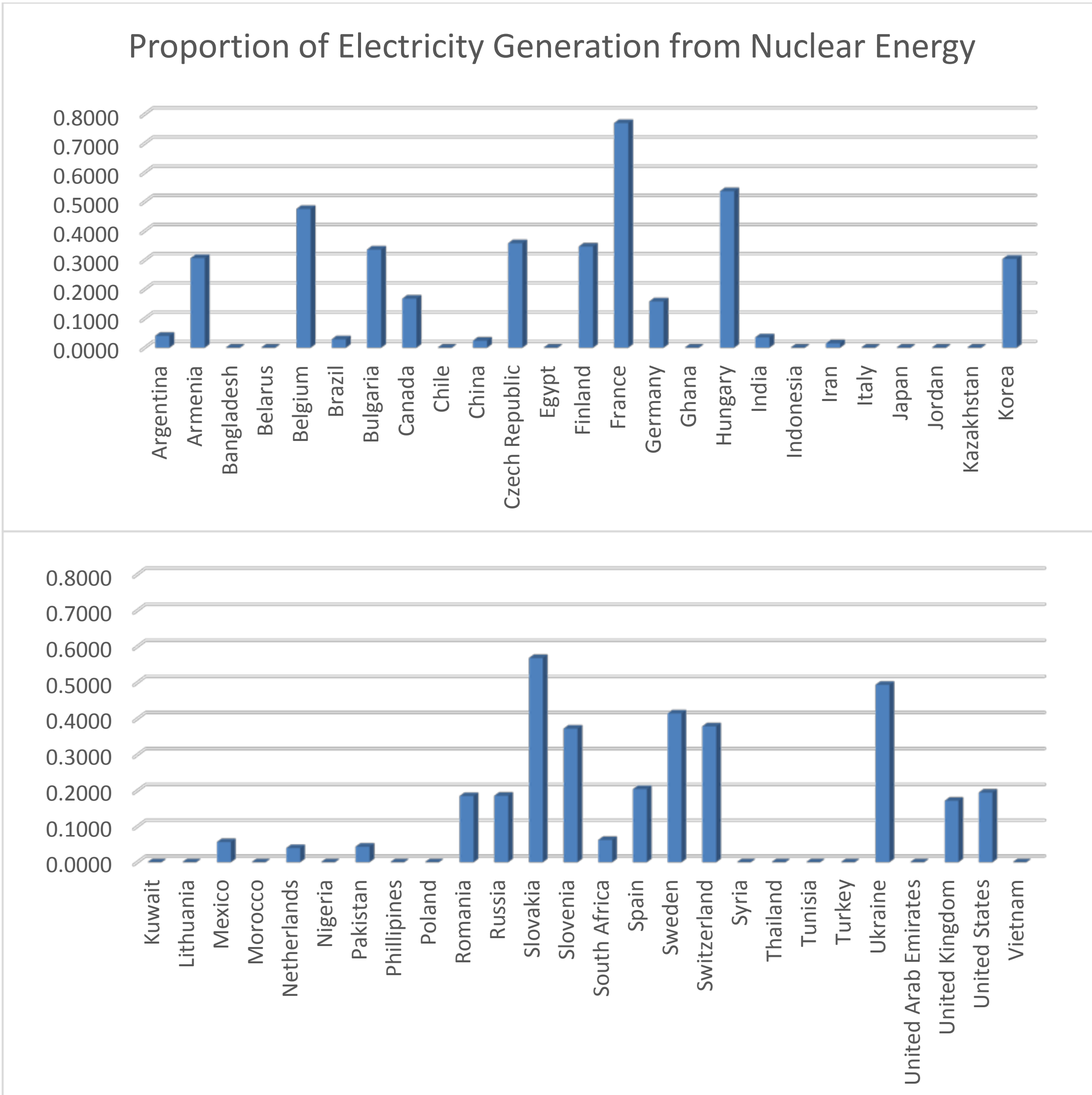
Furthermore, states with an already high reliance on nuclear energy may see their energy security already commended to the investment that is established in the nuclear infrastructure and keep their commitment high. Therefore, states with a high percentage of their electricity generation coming from nuclear energy will already be rooted in their domestic production of energy. In the figure below, the proportion of electricity generated from nuclear energy for each country is charted. What this shows is the dependency on nuclear generation that each country has. The highest dependers are France, Slovakia, and Hungary at above 50%. States that have a bigger proportion of energy coming from nuclear means are able to better hedge for their own energy security because they do not have to procure external energy imports.

Table 4.12: Correlation Energy Security and Nuclear Policy Change

	Pro-Nuclear	Anti-Nuclear	No Change
Energy Security	-0.0402	-0.1091	0.1206

*p<.05 **p<.01
Number of observations: 49

Figure 4.5: Generation of Electricity from Nuclear



For example, France has the highest proportion of any state generating its national electricity through nuclear energy, therefore it is expected that their commitment to nuclear energy would remain strong since. Because their share is so high, they do not have to look to external imports to fulfill their needs. Meanwhile, Chile has a low percentage of energy generation from nuclear, so their commitment to investing is not as strong.

4.1.7 *Hypothesis 7: States that had an executive or legislative election within a year after Fukushima will be more likely to adopt an anti-nuclear policy change.*

Table 4.13: Elections Hypothesis

	Variable	Likelihood nuclear commitment	Likelihood nuclear abandonment	Measure
Elections Factor	*Executive Elections* ↑ *Legislative Elections* ↑	↓ ↓	↑ ↑	Elections within one year of Fukushima

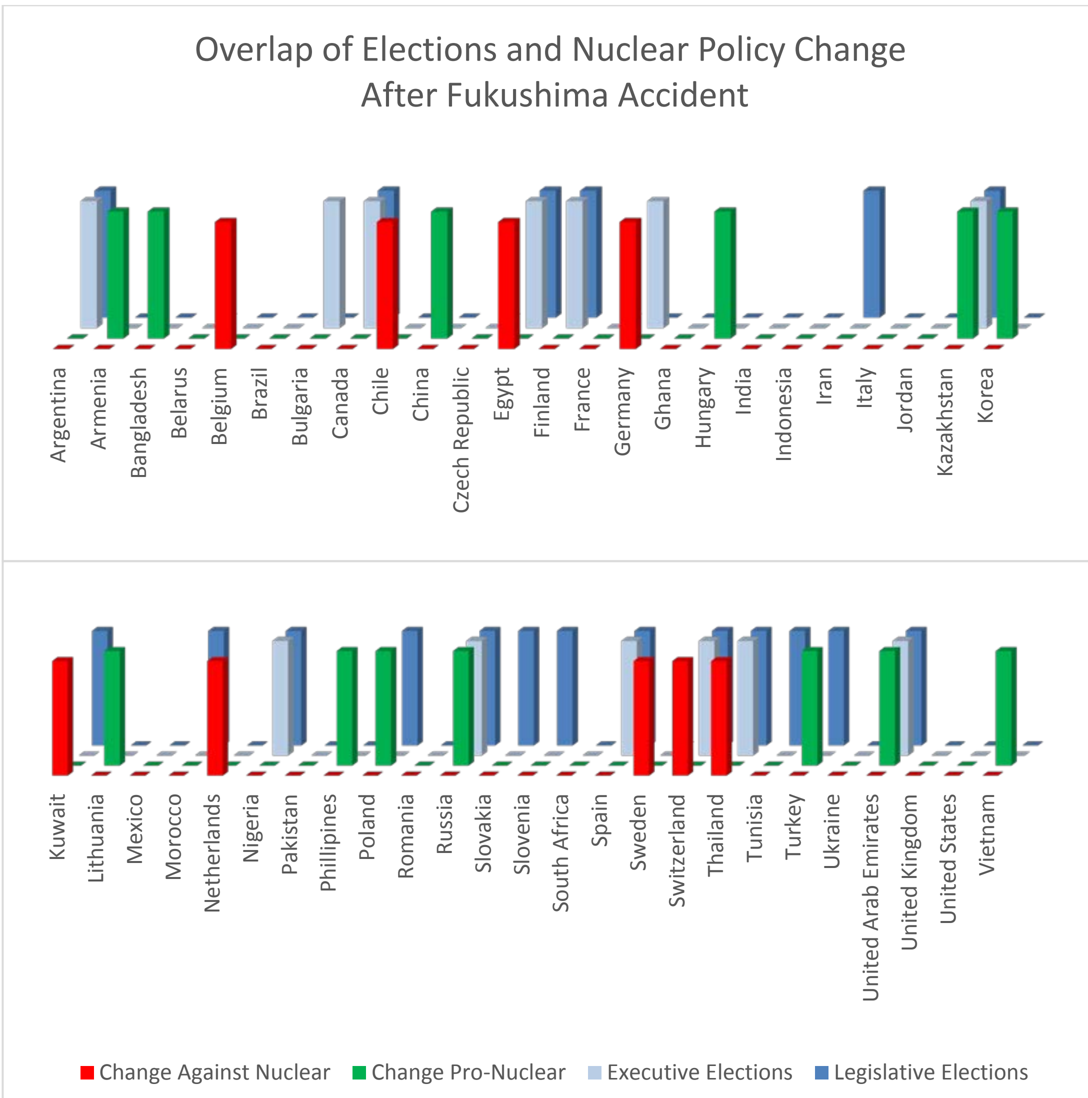
Elections present an opportunity for the input of the citizens to enter the political arena. Additionally, representatives may have to be more responsive to public opinion during elections, as neglecting the populace wants can come at the expense of being voted out. Beyond normative principles in a democracy (as represented by Schumpeter 1942, Pitkin 1967, Dahl 1971), representatives concerned with re-election may perceive incentives to respond to the preferences of the median voter (Downs 1957; see also the idea of "rational anticipation" developed by Stimson et al. 1995) in their policies undertaken. The "responsiveness" literature has, indeed, observed a strong link between public opinion and policy decisions (see Jacobs and Shapiro 1994 for an overview).

Therefore, it is expected that states with elections that took place immediately following the Fukushima accident will have negative portrayals of the accident and these will be reflected in their domestic voting preference. Elections may be one of the most direct forms of participation in political systems, and in doing so assure that public preferences can be taken into account.

In assessing the impact of electoral factors on policy change on nuclear energy, it is more likely that the associated outcome will be negative. Boin, ’t Hart and McConnell (2009) argue that the proximity to elections increases the likelihood that policy change on nuclear energy occurs, but it do not address whether the change will be positive or negative. When the decision to generate nuclear has already been made, the blacklash of public input is often only reflected through the support of candidates that are against nuclear energy. When countries decide to move ahead with nuclear energy, the public is rarely directly involved (with rare instances of public referendums that are voted on before nuclear energy is already established in a state), so instead the recourse left to the public (except in instances of referendums) is to support and vote in politicians who are amendable to their positions and are negative to nuclear energy. Therefore, the elections factor is only investigated here compared to the outcome of negative change about nuclear energy.

In the figures below show the overlap of elections that occurred within one year of the Fukushima accident and the type of policy change that took place. The figure “Policy Change on Nuclear Energy and Elections” accounts for all of the possible overlap. Elections are indicated by blue lines, with light blue bar lines indicating that an executive election took place in the immediate year after Fukushima, and dark blue bar lines on cases where legislative elections within a year of Fukushima took place. The red and green bars indicate a pronuclear (green) or antinuclear (red) policy change on nuclear energy in the country. The hypothesis expects that many blue bars would be overlapped with red, indicating that in countries where elections took place also strongly felt antinuclear sentiments. This holds true in cases like Egypt, Thailand, and Switzerland. Yet several countries that had elections that also experienced pronuclear outcomes like Kazakhstan, Russia, and Poland, and countries that had elections but no policy change like Finland, Argentina, and Nigeria.

Figure 4.6: Policy Change on Nuclear Energy and Elections



The figures below disaggregates the overlap between policy change against nuclear energy and legislative and executive elections in order to show the instance of crossover between elections and antinuclear outcomes. I examined the immediate potential for electoral fallout by looking at the incidence of both legislative and executive elections in the one year period following the Fukushima accident to see where there is potential overlap. In legislative elections, there were four instances of overlap: Egypt, Kuwait, Switzerland, and Thailand. In executive elections, there were also four instances of overlap, but not in all the same countries: Egypt, Germany, Switzerland, and Thailand. From these results we see that elections immediately in the aftermath of Fukushima does not automatically mean that policy change against nuclear, but that the accident may serve as an important outlet for the opening of a policy window.

Figure 4.7: Policy Change Against Nuclear Energy and Executive Elections

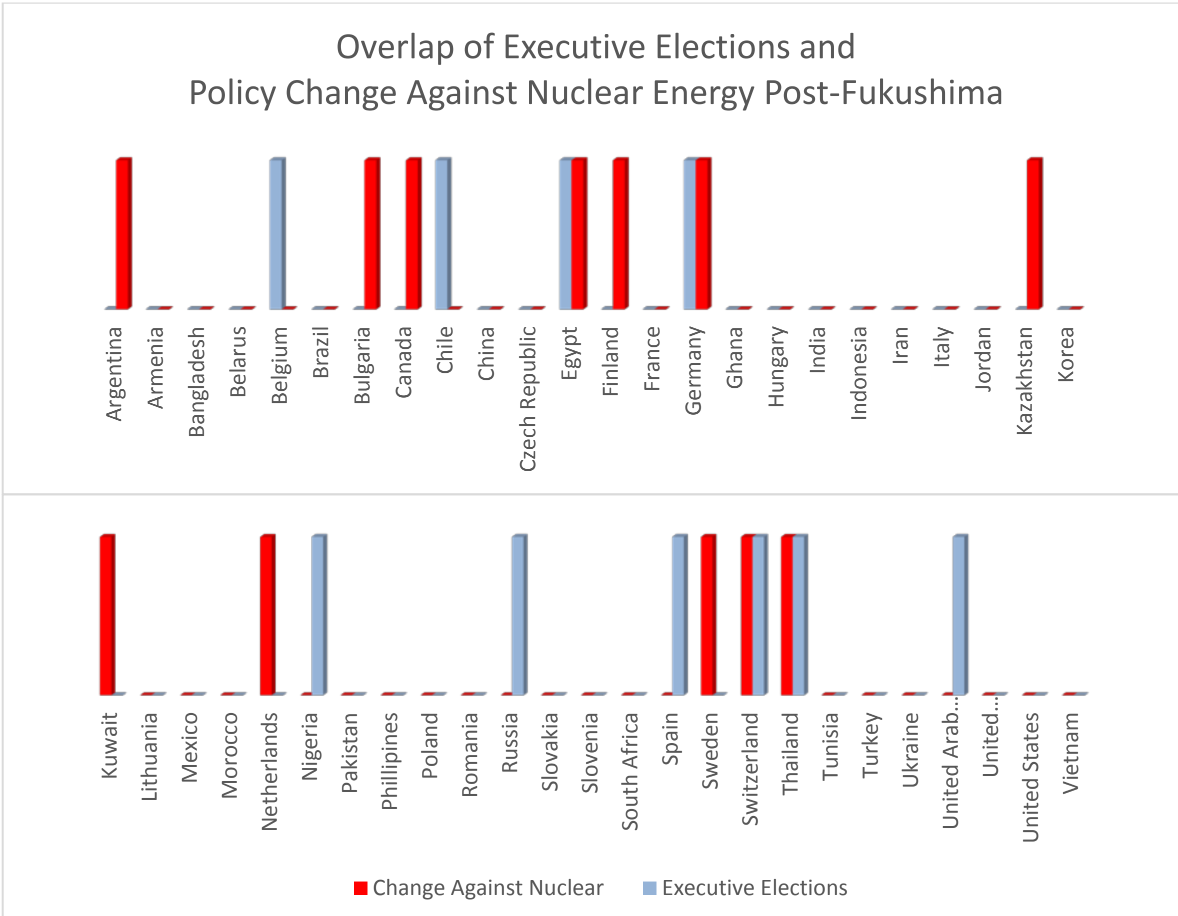
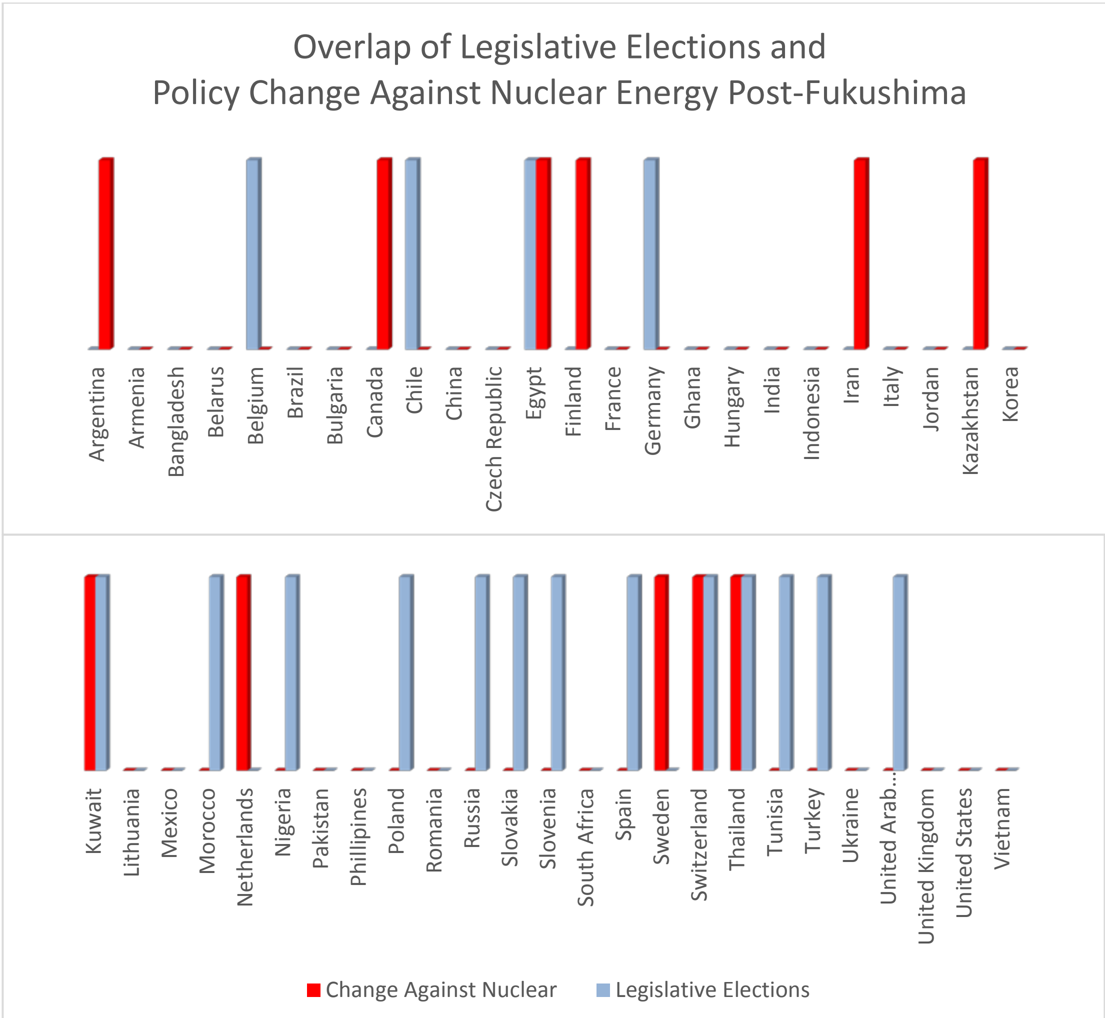


Figure 4.8: Policy Change Against Nuclear Energy and Legislative Elections



States that took a negative stance on nuclear energy following the Fukushima accident may have seen some of the negative association pushed for through their electoral cycle. With the prominence of the election and with issues that the public may have not typically been able to offer direct input, the timing of the Fukushima accident may have brought the opening of a policy window. Because the of the incident's close proximity to electoral politics, the entirety of the national nuclear power program could come up for reevaluation either through party politics (as was the case in Germany with the Christian Democrats and Liberals) or a nation-wide referendum (as has been the case many times in Switzerland). The election process may also keep the policy window open longer in these cases as it might bring a continuance to the issue of nuclear energy for reconsideration.

4.1.8 *Hypothesis 8: States that are democratic are more likely to adopt a policy change against nuclear energy.*

Table 4.14: Regime Hypothesis

	Variable	**Likelihood pro change**	**Likelihood anti change**	**Measure**
Regime Type Factor	*Regime type* ↑	↓	↑	Polity IV
	Democracy ↑	↓	↑	Freedom House
	Freedom ↑	↓	↑	Freedom House

There are characteristics inherent within a democracy that will make opposition to nuclear energy felt more strongly than in autocratic state. States with a greater adherence to democratic principles have a greater responsiveness towards public opinion because of the accountability elected representatives have to their populace and desire to stay in power. The sway of elections (as discussed in more depth above) holds more influence in democratic regimes. Democracies are typically more open and free about the spread of information, even if it is negative about a position the government is in favor of, unlike an autocratic societies. Additionally, and as will be discussed in-depth in the case study chapter, it is perhaps easier for policy entrepreneurs to gain attention and momentum in a democratic context, thereby allowing for another avenue of policy retraction from nuclear energy. Lobbying groups also hold a more prominent position in democratic societies, and so they might be able to seize framing of the nuclear accident more effectively than a context where these groups are nonexistent.

To start with a consideration of how regime type influences policy outcomes, I start with a simple assessment of democracy in a binary fashion. Overall, there are a few conclusions to draw. Of the status quo policy states, the majority were democratic, most likely because the majority of countries examined overall meet the criteria for democracy. The no change variable does not indicate much of interest. However, in the pro-nuclear policy change variable, there was a strong showing of undemocratic countries, and the anti-nuclear policy change retraction countries showed more democratic countries. Even though in the pro-nuclear category the numbers of democratic and non- democratic states were essentially the same, it is noteworthy that the proportion of non-democratic countries is a high. It is possible that in non-democratic countries leaders are less accountable to political pressures. For the anti-nuclear country sample, there was a higher number of democratic countries, but when assessing the overall proportionality the results are comparable. The binary democratic assessment reveals some emerging patterns not have a clear picture of regime type influence on policy change. The direct, binary categorization of regime type may obscure other important factors of regime type that dictate policy change, so a deeper exploration is required to show a clearer pattern.

Table 4.15: Cross Tabulation of Binary Democracy[49] and Change on Nuclear Policy After Fukushima

Democracy Binary	No Change to Nuclear Policy	Policy Change Pro-Nuclear	Policy Change Anti-Nuclear	**Total**
Democratic	23 (47%)	7 (14%)	6 (12%)	**35 (71%)**
Not Democratic	4 (8%)	6 (12%)	3 (6%)	**14 (29%)**
Total	**27 (55%)**	**13 (27%)**	**9 (18%)**	**49 (100%)**

To further explore the evidence of how regime type influences the outcome of nuclear energy policy after Fukushima, I draw upon several different indicators of regime type. To look at the wider range of regime types, I use the Freedom House Index to assess if there are any general trends on the policy directional change taken by states after the Fukushima disaster. The results indicate that more or less "freedom" does not have much of an impact on whether or not a state maintains a status quo policy stance on nuclear energy following the accident. Interestingly, there also does not seem to be much of an effect in states that take a pro-nuclear stance as there are fairly even proportions of states that are more or less free continuing to drive for nuclear power. Perhaps the most interesting results come from the states that choose to retreat on nuclear policy. States that backed away from nuclear energy exist and two ends of the spectrum: either the most free states or the least free. This requires further exploration since there this stance most likely has something to do with the strength of the policy commitment and decision making structure. But what can perhaps account

49 Measurement from Freedom House Index, recoded into a binary variable from democratic threshold established by FHI.

for this divergence is that 1) states that are the most free are responsive to public opinion and electoral accountability and so will be more likely to retract on nuclear energy in light of a bad accident, and 2) states that are more autocratic have more centralized decision making apparatuses that enable easy and swift processing of a negative event to motivate abandonment of nuclear ambitions. Even though there are different mechanisms at either end of the freedom spectrum, the inducements for a backwards change on nuclear energy are similar in each case.

Table 4.16: Correlation Freedom and Nuclear Policy Change

	No Change	Pro-Nuclear	Anti-Nuclear
Freedom	-0.2213	0.3364*	-0.0993

*p<.05 **p<.01
Number of observations: 49

As indicated in a correlation, the states that are less free (higher values on the freedom scale, as more free states are closer to 1) have a statistically significant higher chance of a being pro-nuclear.

Table 4.17: Cross-Tabulation of Freedom[50] and Change on Nuclear Policy After Fukushima

Freedom Scale	No Change on Nuclear Policy	Policy Change Pro-Nuclear	Policy Change Anti-Nuclear	**Total**
(autocratic) 6.5	1 (2%)	1 (2%)		**2 (4%)**
6	1 (2%)	3 (6%)		**4 (8%)**
5.5	1 (2%)	1 (2%)	2 (4%)	**4 (8%)**
5			1 (2%)	**1 (2%)**
4.5	3 (6%)	1 (2%)		**4 (8%)**
4		1 (2%)		**1 (2%)**
3.5		1 (2%)		**1 (2%)**
3	3 (6%)	1 (2%)		**4 (8%)**
2.5	1 (2%)			**1 (2%)**
2	6 (12%)	2 (4%)		**8 (16%)**
1.5	1 (2%)			**1 (2%)**
(democratic) 1	10 (20%)	2 (4%)	6 (12%)	**18 (37%)**
Total	**27 (55%)**	**13 (27%)**	**9 (18%)**	**49 (100%)**

The next investigation of regime type uses a more sophisticated measure of regime with Polity IV data. Among the states that have remained committed to nuclear energy, in the short or long term, there is an even balance among the most autocratic to the most democratic states. This conforms to with what has been shown previously by the other indicators for regime type. Intriguingly, the states that are in the initial

50 Measurement from Freedom House Index

stages of pulling back from nuclear energy are of both more democratic and autocratic regime. But, among the states that have chosen to fully abandon nuclear energy, all of them are the most democratic on the regime scale.

Table 4.18: Correlation Regime Scale and Nuclear Policy Change

	No Change	Pro-Nuclear	Anti-Nuclear
Regime Scale	0.2674	-0.2594	-0.0478

*p<.05 **p<.01
Number of observations: 49

Table 4.19: Cross Tabulation of Regime Scale and Commitment to Nuclear Power After Fukushima

Regime Scale	Committed Nuclear	Nuclear for Now	Abandon for Now	Abandon Nuclear	**Total**
(autocratic) -8	1 (2%)				**1 (2%)**
-7	1 (2%)	3 (6%)	1 (2%)		**5 (10%)**
-6		1 (2%)			**1 (2%)**
-4		1 (2%)	1 (2%)		**2 (4%)**
-3			1 (2%)		**1 (2%)**
1		1 (2%)			**1 (2%)**
4	1 (2%)	2 (4%)			**3 (6%)**
5		1 (2%)			**1 (2%)**
7		2 (4%)			**2 (4%)**
8	1 (2%)	5 (10%)	1 (2%)		**7 (14%)**
9	2 (4%)	6 (12%)			**8 (16%)**
(democratic) 10	3 (6%)	8 (16%)	3 (6%)	3 (6%)	**17 (35%)**
Total	**9 (18%)**	**30 (61%)**	**7 (14%)**	**3 (6%)**	**49 (100%)**

What can be discerned from this result is that only the most democratic states have been able to fully abandon nuclear energy for several reasons. First, the most democratic states will have the greatest sway from public opinion and electoral responsiveness. It is in these countries that the public backlash from the nuclear accident may have been the most profoundly felt and the government was compelled by the public to take action. Second, democratic societies have greater freedom of information and opportunity for dissent among the people. In a more autocratic regime, any reporting of the accident and associated negative connotations may have been limited because of the greater control on information available. Third, because of the greater availability for dissent in more democratic states, there was an increased likelihood that interest groups that were anti-nuclear could seize the negative sentiment from the accident and use it to advance their platforms.

4.2 Section II: Multivariate Analysis

4.2.1 *Quantitative Models*

While taking into account a wider set of potential confounds, I have constructed six models to capture variables among policy change, as well as to do so while controlling for the most likely confounds to each anticipated theoretical relationship. Turning to this kind of analysis is important after looking at each hypothesis variable individually. By solely assessing each factor, an isolated account of each can be understood. But now, there is a need and value to account for all in conjunction with other variables for things have been previously omitted variables or confounded in previous attempts at an assessment of the data.

The models are specified into six separate models, each oriented around a grouping of variables. The models are chosen to reflect different orientations of variables that are important to investigation different hypotheses. The first model as variables selected around indicators of economic conditions so that the factors of the market and growth of the economy are considered as a separate entity. The second model is grouped around political variables as to single out the political contextual factors of importance. The third model is concerned with geographic and structural variables to look as factors like size and scale. The fourth model identifies energy variables to single out from the other conditions. And finally, the fifth and sixth models take a combination of all of the above included variables in different arrangements to see how the conditions can be combined and held with various control factors. The splits among the models reflect an attempt to understand the policy outcomes across multivariate context and see how all the factors hold up in conjunction with one another.

There are potential pitfalls with this approach to the models, and I attempt to overcome them deficiencies to the best possible result. The project employs a relatively small sample size of 49 and accepts certain limitations because of that issue (as addressed in the previous chapter on quantitative research design). Small sample sized models tend to worsen due to list-wise deletion of too much multicollinearity among variables when too many controls are added, and worsen do to biases from the nonrandom sample that results from the list-wise deleted observations that would remain. For these reasons, the variables included in my models were kept limited and broken down along the categories of interest to keep the best possible opportunity for inference.

Table 4.20: Model Descriptions

Model Name	**Types of Variables**
Model 1	*Economic Variables*
Model 2	*Political Variables*
Model 3	*Geographic and Structural Variables*
Model 4	*Energy Variables*
Model 5	*Combination Variables*
Model 6	*Combination Variables*

Each model assesses policy change through the response variables pro-nuclear policy change, anti-nuclear policy change, or no policy change. Model one takes account of economic success variables such as (logged) GDP, GDP growth rate, (logged) population, CINC score, HDI and electricity generated from nuclear. Model two examines political system variables such as legislative and executive elections, regime scale, democracy, (logged) population, media freedom, (logged) military expenditures, CINC score, and HDI. Model three looks at geographic and structural factors such as (logged) distance, (logged) population, (logged) area, democracy, (logged) GDP, CINC score, HDI, and nuclear generation capacity. Model four examines energy factors like carbon dioxide emissions, energy security, nuclear generation share, nuclear generation capacity, CINC, the percentage of renewables generation, uranium production. Model five is a combination of factors including (logged) GDP, electricity generated from nuclear, democracy, energy security, carbon dioxide emissions, media freedom, nuclear generation share, (logged) military expenditures, and number of reactors operating post-Fukushima. Model six is another combination of variables with (logged) GDP, GDP growth rate, HDI, executive and legislative elections, democracy, carbon dioxide emissions, energy security, share of nuclear power, (logged) military expenditures, and (logged) distance.

Table 4.21: Logistic Regression of Pro-Nuclear Policy Change Post-Fukushima

Pro-Nuclear Policy Change						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
GDP	-0.587 (0.801)		-0.186 (0.744)		-0.244 (0.711)	0.528 (2.203)
GDP Growth Rate	1.252** (0.456)					3.183 (2.069)
Population	0.498 (0.950)	-0.194 (0.397)	-0.536 (1.069)			
CINC	-0.306 (27.366)		17.924 (26.678)	26.817 (21.261)		
HDI	14.130 (9.331)	5.112 (5.732)	1.295 (10.097)			38.262 (25.819)
Electricity Generated	-0.001 (0.006)				-0.006 (0.008)	
Executive Elections		-0.891 (1.248)				-3.318 (3.482)
Legislative Elections		0.371 (0.983)				3.692 (2.344)
Regime Type		-0.0318 (0.113)				
Democracy		-0.152 (1.437)	0.585 (1.132)		0.005 (1.035)	-4.393 (4.420)
Nuclear Generation Capacity			-0.305 (0.189)	0.359 (0.483)		
CO2 Emissions				-0.393 (0.346)	0.119 (0.698)	-0.457 (1.987)
Energy Security				0.085 (0.452)	-0.450 (0.650)	2.636 (2.280)
Nuclear Generation				-0.052 (0.066)		
Market for Renewables				-4.203 (5.916)		
Uranium Production				0.0002 (0.0001)		
Area			-0.123 (0.491)			
Media Freedom		0.078 (0.047)			0.057 (0.035)	
Military Expenditures		-4.310 (6.160)			9.03 (0.00001)	
Nuclear Power Share				0.450 (3.700)	4.017 (3.811)	-2.166 (4.202)
Distance			-5.293** (1.891)			-6.248* (3.088)
Military GDP Rate						3.169 (2.703)
Number of Operating Post					-1.309 (1.236)	
Constant	-6.951 (9.917)	-3.657 (9.018)	57.834 (22.635)	3.534 (3.995)	2.511 (12.545)	13.935 (40.069)
Prob > chi2	0.011	0.274	0.002	0.604	0.401	0.0003
Pseudo R2	0.291	0.178	0.426	0.113	0.170	0.630

Table values are standard coefficient estimates with standard errors in parentheses *p<.05 **p<.01 No. obs: 49

The logistic regression models of pro-nuclear policy change showed only a few significant results. Models 2 (political effects), 4 (energy effects), 5 (combination) had no significant results. Model 1, which considered primarily economic variables, only found that the GDP growth rate correlated to pronuclear policy change. Specifically, this result implies that as the GDP growth rate increases, the odds of undertaking pronuclear policy change following Fukushima also increase. But this result only held consistent in the economic indicators model, but not model 6 which also included GDP growth rate as an independent variable. Distance from the Fukushima site was significant across all models (3 and 6). These models indicate that as the distance from the Fukushima nuclear accident site increases, the odds of undertaking pronuclear policy change decrease. That is, the further away from the accident, a country is less likely to be favorable to nuclear power. This result is surprising and contrary to the expected hypothesis (that the closer to Fukushima, the more likely to be antinuclear; the father away the more favorable to being pronuclear power). Aside from the significance across these two variables, there are no other significant results associated with the analysis of pronuclear policy change. Full results are listed in the table "Logisitic Regression of Pro-Nuclear Policy Change Post-Fukushima."

Table 4.22: Logistic Regression of Anti-Nuclear Policy Change Post-Fukushima

Anti-Nuclear Policy Change						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
GDP	1.787 (1.148)		0.626 (0.967)		2.616 (1.409)	8.530 (4.765)
GDP Growth Rate	-0.242 (0.241)					0.685 (0.879)
Population	-0.707 (1.030)	3.158* (1.524)	2.510 (1.756)			
CINC	-156.542 (135.492)		-344.537 (193.589)	-280.930 (171.917)		
HDI	5.106 (9.210)	39.514 (21.231)	33.366 (18.666)			47.990* (25.167)
Electricity Generated	-0.006 (0.010)				2.537 (1.404)	
Executive Elections		4.946 (3.083)				8.197 (5.119)
Legislative Elections		-6.678 (3.605)				-4.205 (3.590)
Regime Type		-0.064 (0.236)				
Democracy		-7.192 (4.197)	-4.244* (2.203)		-4.338* (2.236)	-8.276* (4.380)
Nuclear Generation Capacity			-0.011 (0.053)	-2.062 (1.415)		
CO2 Emissions				1.659 (0.988)	2.616 (1.404)	-9.190 (5.298)
Energy Security				-0.235 (0.469)	2.537 (1.404)	4.984 (2.965)
Nuclear Generation				0.310 (0.215)		
Market for Renewables				6.626 (5.638)		
Uranium Production				-0.029 (0.042)		
Area			-0.835 (0.577)			
Media Freedom		-0.714 (0.097)			-0.1503* (0.072)	
Military Expenditures		-0.0002 (0.0001)			-0.00006 (0.0005)	
Nuclear Power Share					0.866 (5.329)	-7.372 (4.935)
Distance			1.682 (1.817)			2.164 (2.594)
Military GDP Rate						-13.738 (11.531)
Number of Operating Post					-0.181 (1.903)	
Constant	-40.112 (22.016)	-74.144 (38.0621)	-86.591 (38.825)	-19.258 (11.013)	-54.423 (28.565)	-177.958 (93.502)
Prob > chi2	0.057	0.004	0.016	0.127	0.047	0.008
Pseudo R2	0.261	0.530	0.404	0.270	0.399	0.596

Table values are standard coefficient estimates with standard errors in parentheses *p<.05 **p<.01 No. obs: 49

Logistic regression Models 1 (economic effects) and 4 (energy effects) had no significant variables. In Model 2, the political effects model, population size was significant, which implies that as population size increase, the likelihood of a state adopting antinuclear policy stances increased. But population size of a country was not significant in other models. Democracy was one variable that was significant in three of the four models of antinuclear policy change. Models 3 (geographic and structural factors), 5, and 6 all showed democracy to be statistically significant. But, rather unexpectedly, the logit indicates that states that are democratic are less likely to be antinuclear. This is contrary to the hypothesis that democratic states will be more likely to be antinuclear, and the expected relationship is inverse to what the antinuclear policy change models show. In model 5, freedom of the media was significant, with the more restrictive in media freedom a state becomes (a higher value on the index 0-100) the less likely it is to be antinuclear. The inverse of that holds that the more freedom of the media, there is an increased likelihood of an antinuclear policy change. Lastly, in model 6, the human development index was significant. As a state's level of development increases, the likelihood of being antinuclear increases.

Table 4.23: Logistic Regression of No Policy Change Post-Fukushima

No Change						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
GDP	-0.510*		-0.851		-0.790	-2.723*
	(0.708)		(0.970)		(0.674)	(1.330)
GDP Growth Rate	-0.526					-0.612
	(0.250)					(0.454)
Population	0.536	-0.143	0.291			
	(0.799)	(0.355)	(1.123)			
CINC	-3.549		7.908	-11.899		
	(19.355)		(21.102)	(15.319)		
HDI	-6.167	-9.291	-4.222			-21.294**
	(6.589)	(5.154)	(9.039)			(8.362)
Electricity Generated	0.005				0.009	
	(0.005)				(0.007)	
Executive Elections		-0.076				-0.701
		(0.980)				(1.385)
Legislative Elections		0.480				0.422
		(0.871)				(1.009)
Regime Type		0.129				
		(0.118)				
Democracy		0.676	1.577		1.994	2.691
		(1.362)	(1.026)		(1.099)	(1.513)
Nuclear Generation Capacity			0.076	0.030		
			(0.105)	(0.428)		
CO2 Emissions				0.106	0.319	3.200*
				(0.303)	(0.642)	(1.451)
Energy Security				0.270	-0.414	-1.150
				(0.399)	(0.623)	(0.991)
Nuclear Generation				-0.00005		
				(0.058)		
Market for Renewables				-1.087		
				(4.390)		
Uranium Production				-0.00006		
				(0.0001)		
Area			0.754			
			(0.418)			
Media Freedom		-0.013			0.018	
		(0.042)			(0.029)	
Military Expenditures		6.270			-6.820	
		(7.760)			(0.00001)	
Nuclear Power Share					-4.070	4.351
					(3.190)	(2.915)
Distance			2.761*			3.144*
			(1.229)			(1.451)
Military GDP Rate						0.858
						(1.640)
Number of Operating Post					1.317	
					(1.056)	
Constant	10.754	8.672	-12.882	-0.952	15.582	25.425
	(8.737)	(8.051)	(13.580)	(3.567)	(11.804)	(21.361)
Prob > chi2	0.111	0.303	0.005	0.949	0.575	0.009
Pseudo R2	0.153	0.147	0.327	0.041	0.118	0.390

Table values are standard coefficient estimates with standard errors in parentheses *p<.05 **p<.01 No. obs: 49

The logistic regression analysis of status quo nuclear policy (or no change) following the Fukushima nuclear accident showed some significant results. Models 2, 4, and 5 had no significant variables. Models 1 and 6 each exhibited a statistically significant coefficient estimate for gross domestic product. These results suggest that as the GDP of a country increases, there is a decreased likelihood of no policy change. Likewise, and probably for similar reasons, in model 6 the level of human development was significant. As the level of human development increases, the likelihood of remaining status quo on nuclear policy decreased. States that are more developed will be more likely to pursue pro or antinuclear policies. Also in model 6, the level of carbon dioxide emissions was significant. As the level of CO_2 increases, the likelihood of no policy change on nuclear energy increased. Finally, in models 3 and 6, the distance factor was significant. As the distance from Fukushima increased, the likelihood of no policy change increased. Whereas in the pronuclear policy change logit models distance ran contrary to the expected effect, here it is more aligned with the anticipated result.

4.2.2 *Overall Implications of the Models*

The logistic regressions did not yield as many significant results for analysis as anticipated. The policy change outcomes overlapped some, but the results were not consistent across each of the outcome types. While there are some implications for individual variables which will be discussed below, the lack of significance indicates that the hypotheses require additional, qualitative analysis. While this outcome may seem bleak there is an important, overarching conclusion to be drawn: that there are likely other factors not captured by the quantitative indicators that are important for the analysis. The end of this chapter discusses what these possible factors are more succinctly, but to preview, factors about advocacy and political party influence that uncover more about the social dynamics of a country are better captured by qualitative investigation (in the subsequent chapter). The lack of results captured by the models is telling in itself, as it indicates that that there is likely more going on to explain policy change following Fukushima. But overall it does not lend strong evidence to support the prevailing hypotheses on policy change on nuclear energy. And the lack of results that can be taken from the model is a result of other factors that will need to be addressed outside of the thin, narrow description enabled alone by the data and models.

The logistic regression of pro-nuclear policy change did not have many significant results, as expected. Only two variables were statistically significant: the GDP growth rate (which was as expected) and distance (which had the opposite of the expected relationship). The economic growth rate was only significant in the pro-nuclear policy change regression, not the anti-nuclear or no change analyses, suggesting that high growth countries are more likely to be expansionist in nuclear policy. Since nuclear projects require a high level of financing and capital startup, countries that have strong growth face fewer economic constraints than those experiencing a depleted economic situation. Contrary to what was expected, the distance relation to pro-nuclear change went the opposite direction. As the distance from Fukushima increased, the likelihood of pro-nuclear change decreased. This may be the effect of many strongly affiliated to nuclear power countries that were in close proximity to Japan (Russia, Korea, China, etc). The distance factor was not significant in the anti-nuclear logits (where it would be most expected), but it was a significant variable in the no change logit, which indicates that the distance factor overall may not be reliable variable in the Fukushima example. In all, the pro-change logits did not provide for much analysis of the dynamics of post-Fukushima policy change, leading to the conclusion that there are additional factors at play that are not captured by the models.

The anti-nuclear policy change logistic regressions held some interesting implications. Several of the significant variables were as expected with the logic of the hypotheses. Media freedom was as expected, with the more free the media, the more likely of undertaking anti-nuclear policy change. This aligns with the explanations of the role of increased media presence and information availability in shaping policy change. Along these same lines, population size was also significant. As the population size increases, the likelihood of anti-nuclear sentiment also increases, implying that the states with large populations require their governments to be more accountable and responsive. Additionally, in places with large populations, there are potentially more advocacy groups that can organize. The effect of development as measured by the human development index was also as anticipated, with the more developed countries showing an increasing likelihood of being anti-nuclear. The full implications of the role of development in nuclear policy change will be addressed below with the no change logits, but overall expectations about a higher level of human development conforms with the hypothesis about its effect.

The most surprising result from the logits was the significance of the democratic variable in the anti-nuclear change models. It held that democracies are less likely to be antinuclear. Because of democratic accountability and responsiveness, the opposite result would be expected. Why might this be the case? Perhaps this outcome can be explained by a need for further refinement of the spectrum of democracy and nuclear abandonment. The concept of democracy may need to be further disaggregated beyond a binary categorization. Model 2 included a regime scale from autocracy to highly democratic, but it was not significant. This model may have been problematic due to the fact that the dependent variable of anti-nuclear was not specific enough. As explained under hypothesis 7, with the cross tabulation of regime scale and categories of nuclear commitment after Fukushima[51], only the most democratic countries were able to totally forego nuclear power in the aftermath of Fukushima, because they were the most open with regards to information and with the most accountability to their publics. Whereas less democratic states did not take such a stark, resolutely anti-nuclear stance and/or maintained their status quo policies because they did not have the activism or information to fully pullback. Further research that could disaggregate democracy and further break apart the spectrum of anti-nuclear change from total abandonment to a step back in nuclear policy at the moment will better capture what the exact nature of the democracy relationship to policy change on nuclear power.

The no change or status quo policy logistic regressions offer some of the more interesting implications because the results here imply at either ends of the extremes on the spectrum of policy change there are clear determinants for explaining policy change. There were some implications from the no change logits that lend some credence to the expected hypotheses. One of the significant variables was GDP total, and as GDP increases, there is a decreasing likelihood of no policy change. This tells

[51] Table 4.19: Cross Tabulation of Regime Scale and Commitment to Nuclear Power After Fukushima

us that high GDP states are probably going to go to either extreme of the spectrum of either advancing forward with nuclear (China, Russia) or giving it up entirely (Germany). An increased economic weight is advantageous for either pushing forward an expensive nuclear agenda or finding energy alternatives that might a less prosperous country would not be able to invest in.

Another variable that was significant for the no change logits was the level of human development. As the level of HDI increases, the likelihood of no policy change decreases, which indicates that there is an increased likelihood of policy change, either pro or antinuclear. Much like the logic with GDP, when a state is more developed, there is a greater range of options on nuclear policy, since the state has better resources and infrastructure to be able to contribute to their energy infrastructure. In looking at the cross tabulation of HDI categories and policy change, the key finding is that the large number of states that have taken an anti-nuclear policy change all score highly on the HDI. Furthermore, the pronuclear policy change category includes many “high" or “very” high HDI countries. This implies the more highly developed countries are the ones that are at an increased likelihood of undertaking a policy change.

Table 4.24: Cross Tabulation of Human Development and Policy Change on Nuclear Energy

Human Development	No Change to Nuclear Policy	Policy Change Pro-Nuclear	Policy Change Anti-Nuclear	**Total**
Very High	11 (22%)	5 (10%)	7 (14%)	**23 (47%)**
High	9 (18%)	5 (10%)	1 (2%)	**15 (31%)**
Medium	5 (10%)	3 (8%)	1 (2%)	**9 (18%)**
Low	2 (4%)			**2 (4%)**
Total	**27 (55%)**	**13 (27%)**	**9 (18%)**	**49 (100%)**

The chi-square statistic is 3.9045. The p-value is .689597. The result is not significant at $p < .05$.

The no change logits also showed carbon dioxide emissions as significant. As CO2 emissions increase, the likelihood of no policy change increases. It is possible that large carbon producing countries have a hard time abandoning nuclear or switching to other forms of renewables, so they remain with the status quo policy stance. Additionally, the distance factor was significant, but in a different way than the pro-change models. Whereas there the distance effect in the pro-change models was counter to what was expected (the farther from Fukushima, the decreasing likelihood of pronuclear change), in the no change logits the distance factor is perhaps more in line with expectations. As the distance from Fukushima increases, the likelihood of a state maintaining the status quo and not making any policy changes increases. The accident did not really seem to affect the countries in a way dependent on distance.

4.2.3 *Hypotheses Results*

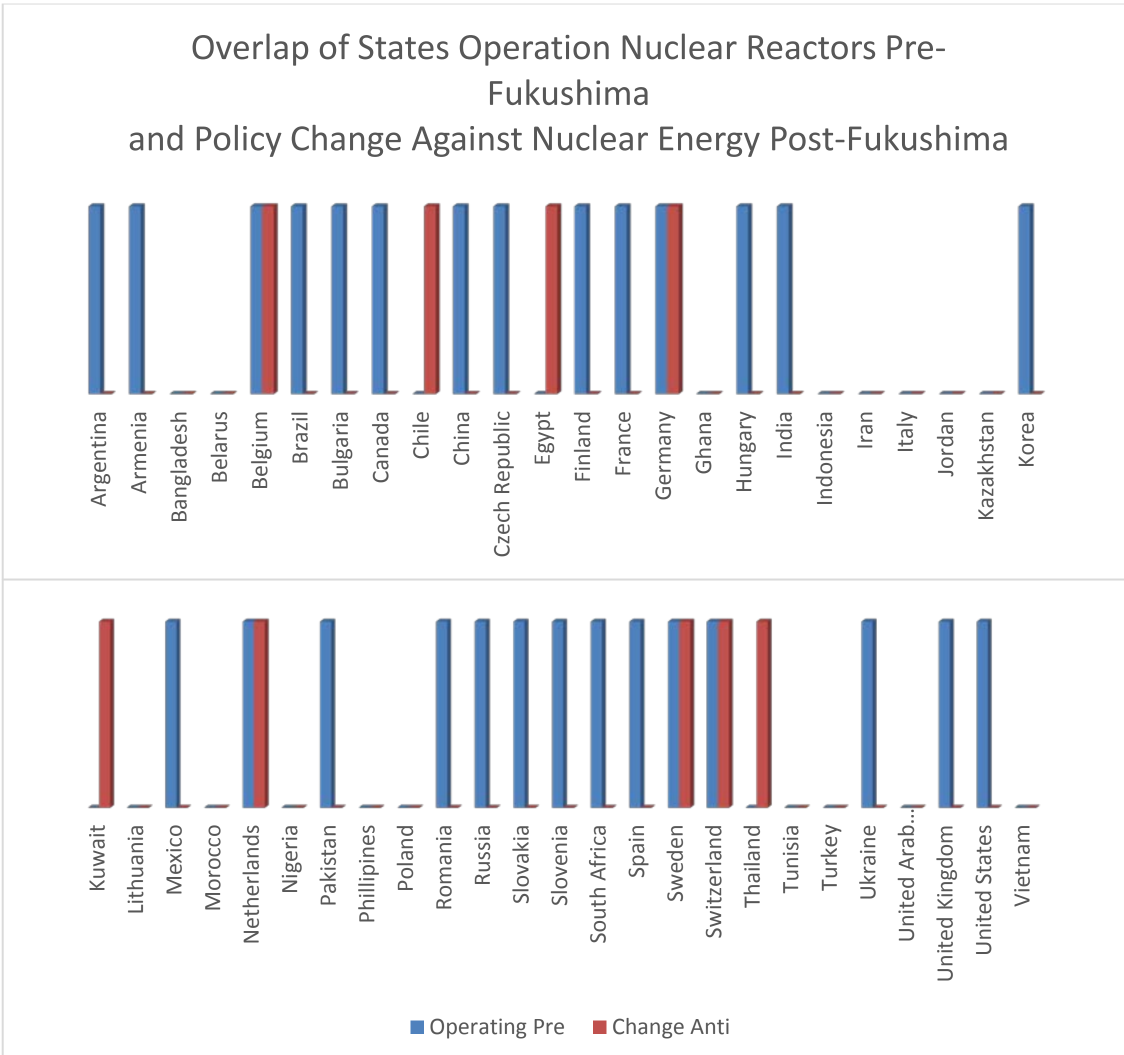
From the quantitative investigation, there is limited evidence to support the hypotheses proposed at the beginning of this chapter. Hypothesis 1, the geographic proximity factor, indicated mixed results, with either distance not mattering for the likelihood of policy change or the opposite causal direction being indicated by the logit models. Hypothesis 2, the climate change factor, expected that as CO2 emissions increased the likelihood of pronuclear change would increase and anti-nuclear change would decrease, but the indicators showed mixed results. The only time CO2 emissions would significant in the models was in the no policy change logits, which was not in accordance with the expected hypothesis. Hypothesis 3, the economic success hypothesis, did see some measure of support from the pronuclear change logits showing agreement with the hypothesis. Hypothesis 4, the power factor did not show any support from the data. Hypothesis 5, the public opinion factor did have some support as the more freedom of the media the increased the likelihood of antinuclear change. Hypothesis 6, the energy security factor, was not supported. Likewise, hypothesis 7, the election factor, did not show a connection to the incidence of policy change either pro or antinuclear. And finally, hypothesis 8, or the democracy factor, shows contradictory evidence. The antinuclear change logits actually indicated that the opposite relationship than expected held, but a cross tabulation of the data broken down into both further democratic categories and into a commitment to nuclear energy post-accident indicates that a refinement of the classification perhaps matters in showing when democracy matters.

4.2.4 *Overall Takeaways*

The overall contribution from the quantitative assessment of policy change following the Fukushima nuclear accident does not point to many general conclusions. The limitations of generalizability may largely be because of what the data may not be able to capture, and thus the lack of results in this area highlight the need for further, thicker descriptive analysis to better uncover what dynamics are promoting policy change. A more thorough investigation of factors that may not have been able to be reflected in the data are then necessary to consider through qualitative case studies (in the next chapter). But for now, we can consider what can be taken from the investigation of the quantitative data and understand how both a broad leveled quantitative analysis can be both useful, but still limited without an explanation of the more nuanced, non-quantifiable factors.

Before assessing the bigger implications of the quantitative analysis, a question must be addressed. Since nuclear power has a massive start up initiation in terms of cost, infrastructure and manpower, it would be reasonable to expect that some of the negative backlash to nuclear energy could be more easily accounted for in the places that did not already have nuclear power generation, where, by extension, it would be easier to change the policy on nuclear power because there was no existing investment.

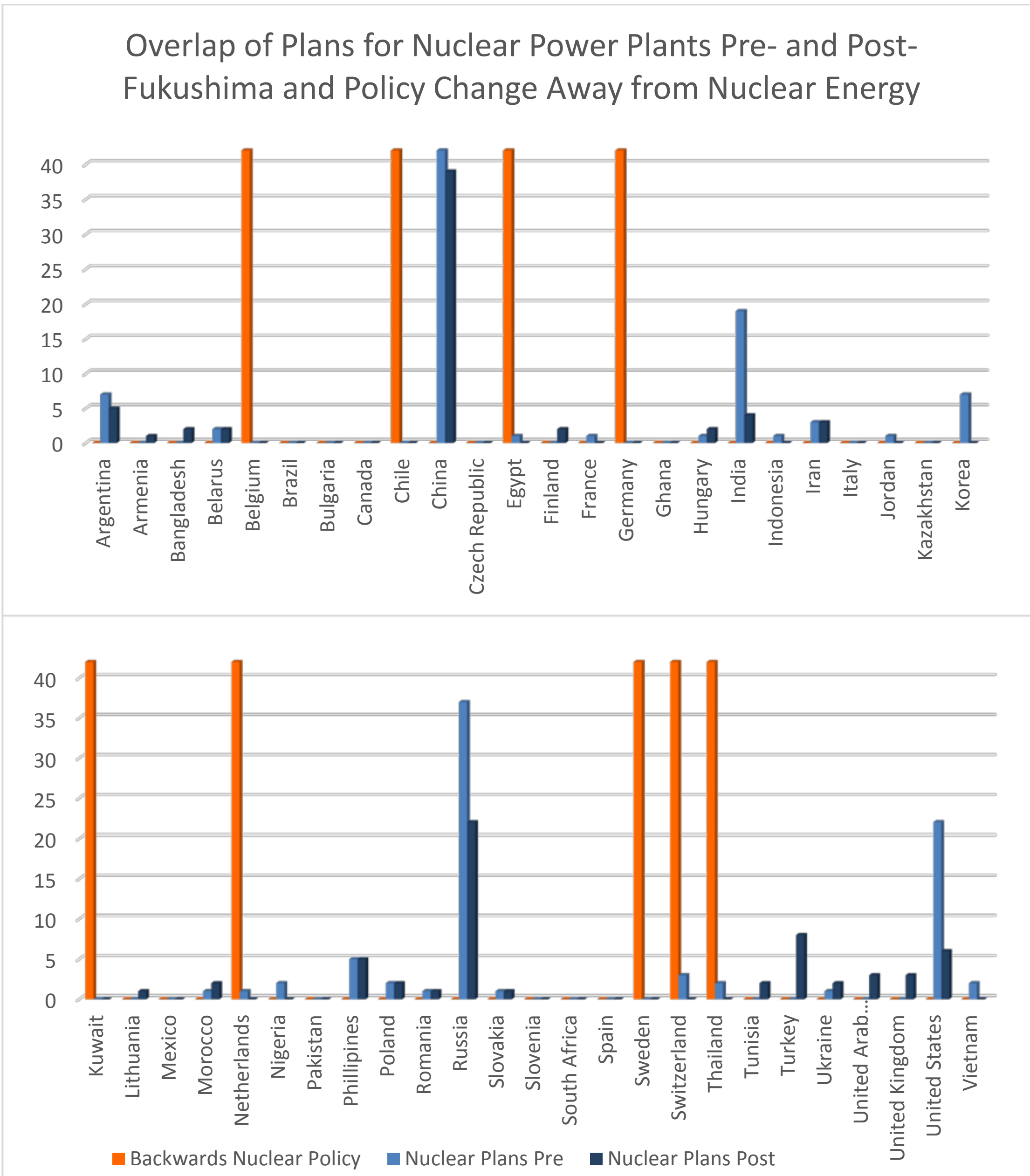
Figure 4.9: Anti-Nuclear Policy Change and Operation of Nuclear Reactors Prior to Accident



Conolley (2011) suggested that perhaps it may be easier for states to abandon plans for a nuclear energy program rather than shutting down already existing nuclear power plants, given the large amount of money put into the nuclear program and the number of jobs in this industry. But as the bar chart above shows, there were almost the same number of states abandoning nuclear power (making an antinuclear policy change) that had nuclear power plants in operation prior to the Fukushima nuclear accident (Belgium, Germany, the Netherlands, Sweden, and Switzerland) as there were that did not have operating nuclear power stations prior to the accident (Chile, Egypt, Kuwait, Thailand). Given that there were equivalent numbers of states that already had nuclear power plants as those that did not, those accounts about the pre-existence of nuclear power do not explain policy change outcomes. So, even preexistent to the other considerations of the data, the claims that the prior operation of nuclear power would factor heavily into the considerations of policy change do not hold sway.

Perhaps, alternatively, where this consideration does make a difference, is when new plans for nuclear power are concerned. The states that are ambitious and active about their plans for nuclear power generation may find it more difficult to pull back, whereas the states that did not have larger plans for nuclear power may be more able to take an anti-nuclear policy change stance. In places that retracted on nuclear policy following Fukushima, none had more than 3 plans in place for new nuclear power plants. Contrarily, in many of the places that had large numbers of planned nuclear plants, there was no pull back away from nuclear energy following the accident. Even in the places that dramatically cut back in the years immediately following the Fukushima accident, if there were still significant plans in place for nuclear power plants that downtick may not have been a conclusive factor to indicate anti-nuclear change. Perhaps countries with only a few plans in place for new nuclear reactors had an easier time forgoing nuclear energy because their reliance or investment into nuclear was not high prior to the accident. Whereas in places where there were longstanding plans in place and years of developed already invested into the nuclear infrastructure, states have a harder time pulling back from nuclear energy.

Figure 4.10: Plans for Nuclear Power and Anti-Nuclear Policy Change



One of the major takeaways is that the nuclear accident at Fukushima did function as a focusing event, but it is not always clear cut how and by what measurable factors shaped policy change. The factors of policy change are not always consistent, which implies that there are other elements that are not captured quantitatively and remain to be uncovered. Perhaps the saliency of the event mattered more in some contexts than others, so finding what those factors are push the next steps for analysis. It is important to consider how policy windows were opened after the Fukushima nuclear accident by extension, how different contexts led to different fruitions. The previously held conventions of what factors are indicative of policy change on nuclear energy do not actually hold up to scrutiny of the post-Fukushima accident context.

There are strengths and weaknesses to undertaking a qualitative evaluation of the question. The goal of comparison is to provide contextual descriptions of the political phenomena we observe, classification for the purposes of classification, hypothesis testing to provide explanations, and finally to predict patterns of observable behavior (Landman 2000). Both qualitative and quantitative research designs can achieve these goals if executed properly. To the benefit of this research, quantitative study can explore a wide variety of cases and factors that might influence potential policy change. However, what is still largely missing and overlooked from the quantitative analysis, are the aspects of how the policy choice and change are part of the agenda setting process. For example, the kinds of information that might be important about the political system, such as how decisions about nuclear energy are processed or how nuclear energy gets politicized. Or, in another example, how the existing inputs into the political process—through advocacy coalitions, green parties/multiparty presence/nuclear industrialization entrenchment—can elaborate on a fuller picture of nuclear process. These issues will be considered with more depth through qualitative study that may be able to better elucidate the results of the quantitative investigation.

Chapter 5

QUALITATIVE RESEARCH DESIGN

As the binary indicators of policy change were not able to provide a full accounting of the factors that promote change in nuclear policy, there are other factors at play that cannot be understood through quantifiable means alone. Additionally, quantitative factors are unable to account for the nuances of actual policy change. Thus there is a need for a qualitative inquiry of the question of study. This chapter proceeds from here by outlining the research design of the qualitative study, justifying the selection of case studies, and providing the framework of the methodological approach. It then turns to an overview the narrative expectations of the cases selected by using a policy window account, consider the inclusion of factors that were unable to be considered quantitatively (such as advocacy coalitions, the strength of nuclear industrialization, and political party system factors) before taking an overall account of the analysis. The subsequent chapter will look at each selected case individually before drawing conclusions for discussion.

5.1 Qualitative Research Design

This chapter explores the question of policy change through selected case studies that provide evidence and thick description of the factors that the quantitative evaluation was unable to take into account. The quantitative analysis looked at policy change and its significance in the post-Fukushima context across a wide sample of countries to see what general trends could be observed. Now the task is to break up the previous analysis into smaller cases that provide more insight into the dynamics of the policy change process. In keeping with the analytical framework from the quantitative chapter, the qualitative study will break down policy change across the outcome categories of pro-nuclear policy change, anti-nuclear policy change, and no change and assess a case example of each: Russia (pro-nuclear), Germany (anti-nuclear), and Canada (status quo).

The benefit of undertaking this comparative case analysis is that it allows for the intense examination of existing data (Lijphardt 1971). Further, such an approach strengthens theory-testing efforts in ways that Large-N methods cannot (Van Evera 1997, Lijphart 1971). While Large-N methods are capable of telling us whether a hypothesis is valid; they cannot tell us why that hypothesis is valid (Van Evera 1997). As this study attempts to assess whether correlations between intervention motive and intervention outcome, as well as how these variables relate to each other, qualitative case-study analysis is appropriate here. While case the case study method is subject to the problem of many variables and few cases (Lijphart 1971, Van Evera 1997, Achen and Snidal 1989), I attempt to overcome this weakness by relying on Mill's "method of difference" approach. I focus my investigation on cases that are similar across numerous factors, but that differ along relative values of the main independent variable (intervening factors about the interaction of the nuclear industry and political system) and the dependent variable (the policy standing outcome on nuclear energy post-Fukushima).

Qualitative analyses allow for what George and McKeown (1985) identified as "process-tracing." This can be defined as the examination of detailed evidence about the causal process that produced the outcome of concern (Munck 2004). In an article appraising the state of the political science discipline, Peter Hall (2003) calls for the development of "systematic process analysis". He suggests that comparativsts have increasingly turned toward an ontological stance that places emphasis on strategic interaction and path dependence. As a result, our ontologies have outrun our methodologies, and within research exists a disparity between how we conceive of the world and how we test the assumptions we are making (e.g. with regression analysis).

I rely on the process-tracing method, which allows for the identification of causal pathways between the hypothesized relationship between industry and political system factors and commitment to policy outcome. This incorporates greater points of analysis than could be examined in a standard case comparative study. It also allows for the identification of causal links between the variables of interest, and as such provides the opportunity to measure their presence and strength at each stage of the hypothesized process (King, Keohane, and Verba 1994, Sayer 1992, Yee 1996, Njolstad 1990, Achen and Snidal 1989, Bennett and George 1997, Dessler 1991, Bennett and Elman 2007). As Hall (2000) emphasizes, "process-tracing is a methodology well-suited to testing theories in a world marked by multiple interaction effects, where it is difficult to explain outcomes in terms of two or three independent variables." (5) Since I analyze the interaction of different components of the political and industrial system, process-tracing will be helpful for this study as it necessitates explaining chains of events, rather than a single phenomenon. Process-tracing links us to the past, present and future.

5.2 Suitability of Cases Selected

As a comparative venture, this project will utilize the method of difference (Ragin 1987, 2000, 2008, Woodward 2003, Baumgartner 2009). With regards to the proposed cases, and potential sampling issues, I rely on ‘purposive sampling’ (Curtis, Gesler, Smith and Washburn 2000, 1002) to make selection, and follow the criteria suggested by Miles and Huberman (1994), and demonstrated by Chien (2013), namely:

- relevant to the conceptual framework;
- potential to generate rich information;
- analytic generalizability;
- potential to generate believable explanations;
- ethics;
- feasibility.

For instance, of all the potential country cases in the world, I need access to material in English to the chosen cases (feasibility), the cases can provide thick analysis (generate rich information) and they are relevant (to the conceptual frame) in that all experienced policy change in response to the focusing event.[52]

The three cases of Russia, Germany, and Canada were selected for this study on the basis of their ability to each exhibit a different policy outcome following the Fukushima accident. Each country shares some similar key attributes but differs in crucial aspects that seem to have been the driving force in that country’s nuclear energy policy options. Since the quantitative questioning of the implications of policy

52 Rather than being indifferent or completely irrelevant due to the lack of nuclear power plants in the country, such as many countries in the developing world.

change follow the same pattern of policy outcomes in terms of anti-nuclear change, pro-nuclear change, and no change, the selection of quantitative cases that follows this same pattern is logical. By selecting each of these examples, different areas of importance can be singled out and developed narratively that were crucial to how they arrived at their policy outcome.

Table 5.1: Canada, Germany, Russia Comparative Standing

	Canada	***Germany***	***Russia***
Population	35 million	81 million	142 million
Geographic Area (sq km)	9,984,670	357,022	17,098,242
GDP	$1.58 trillion	$3.78 trillion	$3.57 trillion
GDP Growth (2014)	2.3%	1.6%	0.5%
Polity IV Regime Scale	10	10	4
Freedom House Rating	Most Free	Most Free	Not Free
Media Freedom Index	12.69	10.24	43.42
Human Development Index	0.902	0.911	0.778
National Capabilities Indicator	0.010683	0.024082	0.039274
Energy Security Needs	Exports 67%	Imports 61%	Exports 75%
CO2 Emissions	499 million mt	745 million mt	1,741 million mt
Military Expenditure GDP	1.0%	1.2%	5.4%
Military Expenditure Total	$15 billion	$39.3 billion	$66 billion
Renewable Generation	397 billion kWh	143 billion kWh	168 billion kWh
% Energy Used Is Renewables	24.5%	11.2%	8.1%
% Nuclear of All Electricity	16.8%	15.9%	18.6%
Distance (from Fukushima)	3517 miles	5372 miles	505 miles
Elections (within 1yr Fukushima)	Executive and Legislative	Executive	Executive and Legislative

All three countries are similar in terms of geographic size and population, have relatively high GDP, are members of the G8 (indicating they share a similar level of prominence in global economic and political affairs), experienced GDP growth, have reasonable levels of human development (though Russia lags behind), had elections within a year of the Fukushima accident, and perhaps most importantly, all generate between 15-20% of their electricity using nuclear power. The similarities establish a benchmark for comparison between the cases, in part because they are large, prominent industrialized nations.

However, the countries are different in several key ways. Canada is the smallest of the three in terms of population, GDP, national capabilities, and military expenditures. It also emits the least amounts of carbon dioxide of the three cases, at just under 500 million metric tons. However, Canada has the largest GDP growth rate, renewable generation (by at least double that of Germany and Russia) and use of renewable energy. Also of note is that Canada is an overall net energy exporter. Germany, in contrast, is the only net energy importer of the three cases. It is also the sole country case that had executive elections (not both executive and legislative elections within a year of the Fukushima accident). Germany the smallest generator or renewables among the three. But in other respects Germany has the largest GDP, the highest media freedom rating, and is the furthest geographically from Fukushima. Finally, Russia is the closest geographically to Fukushima and fares the worst in GDP growth, freedom or regime score, and media freedom. Despite generating a high number of renewables, Russia was the lowest in energy usage of renewables, indicating that they are a large net exporter of energy. Russia is, however, the largest country in population, area, emissions of CO2, and military expenditures.

Below is a brief overview of how the three countries compare on nuclear issues.

Table 5.2: Canada, Germany, Russia Nuclearization Comparative Standing

	Canada	***Germany***	***Russia***
# Plants Operating Pre	18	17	32
# Plants Operating Post	19	9	34
Electricity Generated	91 TWh	94.5 TWh	166.3 TWh
Generation Capacity	13.5 GWe	12.1 GWe	23.6 GWe
Uranium Production (2014)	8998 mt	50 mt	2862 mt
Uranium Resources (Overall)	650500 mt	7000 mt	689200 mt
Uranium Requirements	1600 mt	2000 mt	3800 mt
Uranium Market Exploration	$873,112,000	0	$56,217,000
Uranium Industry Employment	2400	1204	10335
Nuclear Weapons	No	No	Yes
Generation Pre	90658 kWh	140556 kWh	170415 kWh
Generation Post	94862 kWh	99460 kWh	170415 kWh
Plants Construction Pre	0	0	11
Plants Construction Post	0	0	9
Plants Planned Pre	0	0	39
Plants Planned Post	0	0	22

Russia clearly has the largest nuclear industry of the three cases, and shows a strong industrialization of the nuclear economy. Russia has the most number of nuclear plants, generates the most nuclear energy, has the most uranium reserves, requires the most uranium for its reactors, employs the most people in the uranium industry, and is the only country of the three prior to or after the Fukushima accident to have plans or active construction on new nuclear power plants. Additionally, and critically, Russia has nuclear weapons, which is an area of additional nuclear infrastructure that promotes increased nuclearization of the state. In comparison, Canada and Germany have do not have nuclear weapons, nor did they have plants planned or under construction prior to or after Fukushima. After the accident, both countries generated approximately the same amount of nuclear energy, requiring relatively similar levels of uranium. They differ significantly however in terms of the overall size of their uranium markets, with Canada outranking Germany in terms of uranium mining and exploration and employing double the number of people in the uranium industry. Likewise, Canada added an additional nuclear plants as Germany shut down plants. Meanwhile, Russia maintain extensive nuclear capacity. The differences in the nuclear industry in each of the states show important levels of comparison and differentiation. The level of commitment to nuclear infrastructure that Russia maintains is clearly demonstrated, while Canada has maintained consistent levels of production, and Germany's lack of uranium market, supply, and industry combined with its ratcheting down of nuclear energy show following Fukushima the country had little difficulty scaling down its nuclear capacity.

5.3 Framework for Case Studies

The qualitative case studies follow a set of expectations about the dynamics of policy change. Using process tracing, the case studies establish a pattern of behavior and mechanisms through which to observe the Fukushima accident and policy change outcomes. To accomplish the process tracing, the structure for each case study will follow a common investigation outline, with sections dedicated to the origins and development of the state's nuclear program, a discussion of the immediate pre- and post-Fukushima standings of nuclear policy, and a step-by-step account of each state's plans for a nuclear future.

The common framework through which each country will be examined is depicted in the following figure. First, the Fukushima accident occurs, drawing attention and consideration to nuclear energy worldwide. The accident functions as a focusing event for nuclear energy, bringing increased attention to the issue area and proceeding to open a policy window where action can be taken. From there, a combination of factors promotes a policy change outcome of either pronuclear, antinuclear, or status quo policy choice. These variables configured in different arrangements that shape different policy change outcomes:

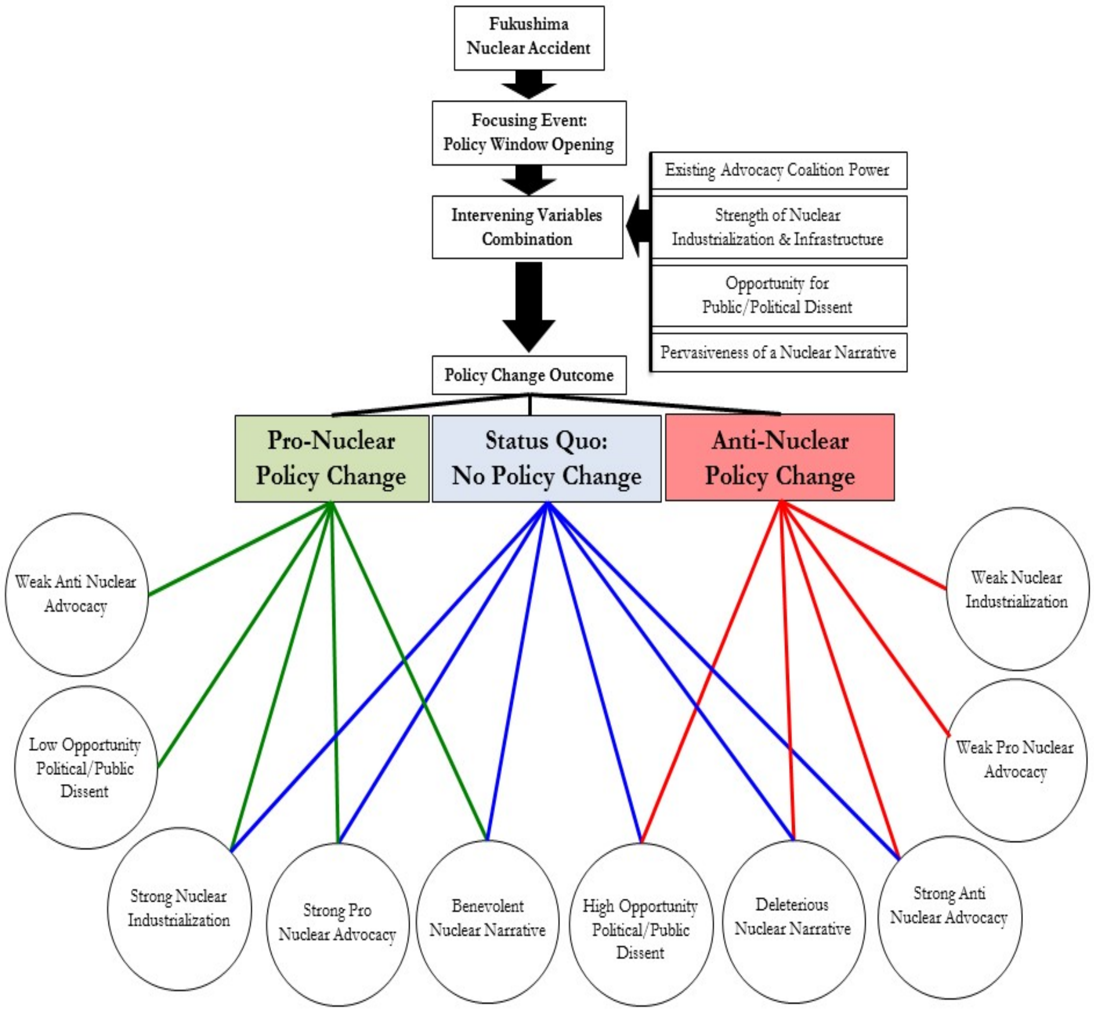
1) developed existence of advocacy coalitions,

2) strength of the nuclear industrialization and infrastructure,

3) opportunity for public or political dissent, and

4) construction of the "nuclear narrative" of a country.

Figure 5.1: Policy Change Outcomes Mechanism



How did the Fukushima accident open policy windows and lead to potential policy change? Each step of the process will be further examined in detail now. Firstly, the Fukushima accident opened potential for countries to conduct a reevaluation of national nuclear programs by bringing increased attention and prominence to concerns about nuclear energy that may have previously been latent in the existing policy landscape. Focusing events can change the balance of power and help previously disadvantaged groups gain momentum. Political groups responsible for the current status quo have a hard time defending existing policies in a charged, politically embarrassing environment. In principle, focusing events constitute an opportunity for change, even if they do not always result in actual change. To use the words of Kingdon (1995) a “window of opportunity” for policy change opens up as an issue gains attention and moves up on the agenda. The Fukushima disaster was one of the worst nuclear accidents in the history of nuclear operation, and the magnitude of the event brought a seriousness and prominence to nuclear energy as an issue area in the international context. The policy window opening brings the opportunity for different intervening variables to interact, which in turn lead to different types of policy change outcomes. Four intervening variables are identified as crucial in the process tracing of these case studies.

5.4 Hypotheses

Firstly, the existence or development of advocacy coalitions within a state can illuminates the type of policy change outcome that a state will undertake. Advocacy coalitions are the arrangement of organized groups, civil society, political agents, and others with a common interest area and forge partnerships to advance their set of policy beliefs and goals. In the nuclear power policy arena, advocacy coalitions form around a common belief about the presence and future of nuclear power and may include inputs from public policy think tanks, activist groups, civic associations with a policy orientation, and political parties. Participants with a well-developed advocacy coalition will be most effective in advancing momentum of policy goals as they will have more experience, resources, and connections to commit to their cause than weakly developed or nonexistent coalitions. Advocacy group can advocate at their disposal either pro or antinuclear, and the strength of the coalition can be weak or strong. As such, there are different configurations and contributions that advocacy coalitions contribute to nuclear policy making.

- *H1.1: Countries with a presence of only strong antinuclear advocacy and a weak pronuclear advocacy will be more disposed to antinuclear policy change*
- *H1.2: Countries with a presence of only strong pronuclear advocacy and weak antinuclear advocacy will be more disposed to pronuclear policy change.*
- *H1.3: Countries with a presence of both strong pronuclear and antinuclear advocacy will be more disposed to assuming a status quo no policy change stance.*

The hypotheses expect that the strength of the affiliated advocacy coalition will make a difference in the type of policy change that is taken. In the presence of only one prevailing advocacy position the policy change outcome will likely align with the dominant opinion. But in the instances of dual, competing advocacy where the presence of both groups is strongly developed the effect of each will effectually counterbalance each other and the results will be a status quo assumption of policy direction.

Secondly, the strength of the existing nuclear infrastructure and industrialization can have an impact for the direction of policy on nuclear power. For states that heavily rely on nuclear components, be it through power, weapons or uranium mining and refining capabilities, they have an attachment to nuclear that provides an incentive to stay committed to a pronuclear policy stance. Many states developed nuclear power through a pre-existing nuclear weapons infrastructure buildup, which has the benefit of adding additional inputs into the nuclear fuel cycle, making it easier to ensure a steady stream of supply and technology necessary to maintain the upstart and stability of power generation. When developing the necessary components and refined uranium for the production of weapons grade nuclear capabilities, the additional labor intensive work to produce and refine uranium for power purposes can easily be diverted for power production. Additionally, the existence of a national uranium mining, manufacturing, and refinement industry ensuring a consistent supply offers a strong draw for nuclear power. This is especially true in an era where energy security concerns are increasingly prevalent. From this, the some assumptions follow:

- *H2.1: Countries with strong nuclear industrialization and infrastructure will be more disposed to a pronuclear policy change or a status quo no change continuance of nuclear policy.*
- *H2.2: Countries with weak nuclear industrialization and infrastructure will be more disposed to antinuclear policy change.*

When both nuclear infrastructure and the related industry have been strongly developed, a pronuclear policy change is a stronger possibility for several reasons. The larger the nuclear industry, the larger the lobbying power and potential to promote the viability of nuclear energy. There is more preexisting money invested in keeping the industry robust and a change in policy would be disadvantageous. Furthermore, when the nuclear sector is tightly connected between, weapons, power, and uranium industries, there is a stronger supply potential of power generation. All of these factors will impact potential for policy change on nuclear power.

Thirdly, the opportunity for public and political dissent shape the potential for policy change on nuclear energy. Public opinion on nuclear power has long been recognized by scholars as a crucial factor in understanding policy choice, as polls can account for and several referenda in various countries can attest to on the subject of nuclear power pursuance. Having avenues for public discourse and accountability can levy a significant shadow on the way that nuclear power is perceived, received, and retained. As powerful demonstrations show, public avenues of discontent has the potential to communicate unpopular sentiments to policymakers who are accountable and responsive to their constituents and then take that input to their policy decisions. Additionally, in general, the space for political dissent is important for the potential for policy change. Thus, two expectations can be derived:

- *H3.1: High opportunity for public or political dissent promotes more antinuclear policy change or status quo no policy change.*
- *H3.2: Low opportunity for public or political dissent promotes more pronuclear policy change.*

States with high public or political dissent have stronger pathways for the incorporation of the public's viewpoint of policy matters. This in turn makes policymakers more accountable for their policy choices and the sentiment more likely to be of an antinuclear variety if the public decides to use its conduit. But in some cases, environments with potential for dissent do not guarantee antinuclear resistance. For example, just because is the opportunity for dissent within a country exists, the public may not necessarily take advantage of it. Sometimes the institutional structures exist to give the public opinion a voice, and for whatever assorted reason the public is not particularly loud with that voice. In this case, it is possible for a country to take on a merely status quo stance on policy. Inversely, when there is low potential for the dissenting public or political entities to engage in discourse (often because of government repression of speech or liberties), there is less of a chance for antinuclear sentiments to fester and enter the political arena and policy makers to take change. In these cases it is more likely for countries to promote pronuclear policy change.

Fourth and finally, the pervasiveness of a "nuclear narrative" in a country has the potential to shape the way that nuclear issues are received in the historical, political, and social context, and how the prevailing narration around nuclear energy projects on to policy decisions. Nuclear energy has a "personality" that other types of energy generation do not, as shown through the various depictions of nuclear power in popular culture.[53] This personification of nuclear energy characterizes the perception of risk and in turn influences states' abilities to pursue nuclear energy. Thus, this type of narrative surrounding the characterization of nuclear issues may have a strong grasp on the way that nuclear power is portrayed and accepted, either in a manner that is benevolently peaceful or destructively harmful in its prospects.

- *H4.1: A pervasive narrative that portrays nuclear energy in a benevolent light will be enabling of more antinuclear policy change*
- *H4.2: A pervasive narrative that portrays nuclear energy in a deleterious light will be enabling of more pronuclear policy change.*

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53 Nuclear power has been depicted more in pop culture than other types of energy. Examples such as in manga series like *Astro Boy*; comics like *Wolverine*, in films such as *The China Syndrome* (1979), *Barefoot Gen* (1986), *Chernobyl Diaries* (2012), and *Godzilla* (2014); satirized in television shows such as *The Simpsons*; and in poems and popular literature such as *The Crazy Iris* (1984). Whether for humor or dramatic effect, these portrayals leave a lasting impression upon those who receive them.

- *H4.3: Status quo no change nuclear policy may experience either a nuclear narrative that is favorable or unfavorable towards nuclear energy.*

Narratives that look favorably on nuclear energy focus on the more positive, helpful aspects of nuclear power. They emphasize that nuclear power is beneficial as a power source in that it does not emit carbon dioxide, has a relatively safe and stable operating record, can be good for the generation of the local and national economy, is prestigious and brings with it other technological developments in medicine, transportation and defense along with its progress, and it is reasonably cheap through its overall lifetime of generation. By contrast, narratives that focus on the more negative, aspects of nuclear power insist that it is not truly a form of clean burning energy, has vast potential for calamity to humans and the environment when an accident does happen, brings potential safety concerns of worldwide weapons proliferation, increases danger to local residents with small releases of radioactivity, and is exceedingly expensive to build. While there may be truth in both contesting narratives, the balance of one over the other in a society can seem as the enabling factor to induce policy change in the opening of a policy window.

The varying configurations of intervening variables have overlap convening in the three policy change outcome categories, as the arrangement mentioned above depicts. These are the defining mechanisms through which the process flows forward from the opening of the policy window from the Fukushima nuclear accident to the policy change outcome a country assumes. Moving forward, the three countries selected, Russia, Germany, and Canada, will be examined for their nuclear history, experience pre- and post-Fukushima, and future prospects for nuclear energy. While the three countries chosen represent a subset of the cases available for study, they will allow for an evaluation of the different experiences with nuclear and where the nonquantifiable, social aspects of experience with nuclear energy come into play as countries grapple with policy choices. As the experience from the quantitative chapter analysis showed, there are not clear cut broad implications that can be drawn from the available data on the drivers of policy change after Fukushima. As such, delving more deeply into the social drivers of policy change gives a new prospective for best understanding how nuclear accidents, specifically the Fukushima accident, can function as a focusing event that opens a policy window to allow for different configurations of policy change depending on the existing set up of variables.

Chapter 6

CASE STUDIES

The case studies presented represent the experiences with nuclear power in Russia, Germany, and Canada before and after the Fukushima accident. Full dissertations could be written on each country case alone, and as such the brevity of the treatment of each subject is well known and appreciated here. Each country functions as a “micro” case study that focuses on the relevant parts of each case that expose the logic of focusing events and the mechanisms that contributed to their policy outcome following the Fukushima accident. The goal here is to provide “thick” description to uncover the dynamics of policy change that quantitative investigation was unable to provide. This chapter proceeds as follows: first, it explores Russia and its nuclear development in conjunction with a weaponization infrastructure, followed by its expected performance immediately prior to and after the Fukushima accident, and finally to its future in the nuclear industry, especially with regards to its export of nuclear technology. Then, the study turns to Germany, where strong public antinuclear sentiment existed since the inception of the nuclear industry, and how years of political maneuvering by parties and coalitions brought advancement and retraction of a nuclear phase-out brought a unique opportunity in the aftermath of the Fukushima disaster. As a final country case, I examine Canada, with a particular emphasis on the long standing balance between pro- and antinuclear sentiments, which resulted in an effective standoff between factions to adopt real deviations on nuclear energy policy. I concluded with the overall takeaways from the comparison of the country cases about their ability to deduce policy change after a nuclear accident.

6.1 Part I: Russia

6.1.1 *Development of Nuclear Power in Russia*

The development of the nuclear power sector in Russia stems from the country's atomic weapons program from the Second World War. Russia's effort largely concentrated on the swift and sophisticated development of nuclear weapons, especially after the acceleration of American weaponization progress forced the Soviets to play catch up. From the beginning, the government saw the nuclear industry as a large scale government-promoted project. In January 1946, Stalin supposedly said that it was "not worth spending time and effort on small-scale work" on the nuclear endeavor, signaling from the highest levels of government that the advancement of nuclear capabilities was to be extensive in scope. Such an effort required much form the Soviet scientific and engineering establishment to "conduct the work broadly, on a Russian scale, and that in this regard the broadest, utmost assistance" would be provided by the state, especially in an "investment of a decisive quantity of resources." From its inception the production of a nuclear infrastructure was a national priority and, beginning in 1946, the construction of an atomic bomb would become the highest priority of the Soviet Union's political leadership, higher even than reconstruction of the damage inflicted by WWII (Duke 2010, 22).

Secrecy and By "Whatever Means Necessary".

The Soviet nuclear program can be characterized by both its remarkable secrecy and its willingness to pursue goals by whatever means necessary. These characteristics have significantly altered the Soviet experience and sent lasting reverberations throughout its nuclear infrastructure in terms of power, weapons, and waste management (Duke 2010, 24). The Soviets expected the nuclear program to bring global prominence to the nation through technological prowess by capable weapons but also by power production. In doing so, it required a massive effort that by the late 1940s saw the cooperation of more than 400 engineering and scientific research institutes, construction bureaus, and other organizations. During the Cold War, the Soviet Union created entire closed cities (at least ten are known for certain) dedicated to the most secret nuclear research and effort, commonly referred to as "Atomgrads." Surprisingly, the big initial nuclear push that followed immediately after the bombings of Hiroshima and Nagasaki did not include the participation of the military. The committee set up included specialists from science and industry, and the party, secret police and civilians were put in charge of oversight insuring that the entire process was shrouded under a clandestine veil. A major concern for the Soviet government was that the effort would be thwarted by Western spies, as atomic espionage in that era was a common practice (and the Soviets owed much their progress on atomic bombs to atomic espionage). As a result, they developed massive infrastructure around the nuclear program, and it was clouded in the utmost control and mystery.

This concealment of the Soviet atomic effort from the public at large made it easier to adopt a dominating push for progress by whatever means necessary. The Soviet scientific and engineering culture was well funded and sophisticated, but brought hubris and unnecessary risk to its technological momentum that created a disregard of health, safety and the environment. In the nuclear industry, this effect was quite pronounced because of the total secrecy involved (Josephson 2000, 272). In its early development years, the Soviet Union experienced many industrial nuclear accidents which "were caused by the feverish pitch of the work, which emphasized speed over safety and productivity or prudence" (Duke 2010, 25). It is estimated that in the first decade alone, the Soviet nuclear program was responsible for between 50,000 to 100,000 deaths.[54] But the government considered these deaths as part of the effort towards advancing the dire need for nuclear capability and did not hold but the Soviet nuclear effort. "During the Cold War, technological prowess was an important indicator of the strength of the communist system, and the broad application of nuclear power could, in the estimation of the Soviet leadership under Leonid Brezhnev (1906-1982) and his immediate successors, demonstrate the superiority of the USSR in the world arena" (Duke 2010, 29). Additionally, in the era of "atoms for peace," establishing peaceful nuclear technologies was a crucial peace for being seen as a progressive, industrial, and pacificist country. The Soviet Union believed nuclear power would bring prestige and security to the country in world affairs. In the government's mind, nothing would get in the way of that.

[54] This estimated figure is largely attributed to early Soviet uranium mining efforts. Lavrentiy Beria (1899-1953), Stalin's chief of secret police who later came to oversee the Soviet atomic bomb project, was well known for the expansion of Gulag labor camps during his tenure of political power. With his administrative overlap of prison labor and the nuclear project, he used Soviet prisoners to solve for the issue of mining for uranium in concentration camps, and prison laborers used little or no protective layers or measures to preserve their health, amounting to the large number of deaths in the early nuclear effort.

Creation of Technologically Advanced Bureaucracy.

To cope with its nuclear imperative, the Soviet Union had to create a monumental infrastructure to accommodate such a wide scale task. The question of how to administer the civilian nuclear power industry was debated at length by scientists, politicians, and economists, and eventually the rise and role of the technocrats was instituted as a the most rational form of organization. With many different moving agencies and organizations (which, as stated previously, were not military affiliated—at least not at the beginning), the authoritative and centralized bureaucratic nature of Soviet communist organization was primed to step in to fill the void and treat the nuclear industry like another produceable, infallible, and manipulable engineering project. The forefathers of the nuclear industry intended it to be similar to the other Soviet mass production industries, where they "could link together a series of simple technologies through complex processes they had tamed in the laboratory" (Josephson 2000, 2). The Soviets developed a centralized planning authority around nuclear, as it was thought "the key to organizing the civilian nuclear sector was to craft an effective bureaucracy to deal with uncertainty, crisis, and the allocation of responsibility" (Schmid 2015, 42). Concern for the public or safety was largely not present as the "decision making in the Soviet nuclear power industry was highly centralized and concentrated in the traditional organ of Soviet economic administration… Those oversight and regulatory institutions that did exist were largely tied to the interests of the power ministry. As a result, over time the Soviet nuclear power industry developed at a rapid pace, with cost reduction and speed of the construction primary considerations for decision-makers" (Dodd 1994, 137). This bureaucracy was largely managed by technocrats, as a way of further entrenching the idea that science and production could be upheld by the means of communist manufacture. At the time, the industry had to handle creating an entire infrastructure dedicated to all things nuclear, while at the same time heavily relying upon individual expert knowledge; they ended up compromising that bureaucratization with key individual experts with the support of extensive networks behind them would guarantee the best form of the organization.

Initially, the Soviet nuclear infrastructure was grounded in the production of nuclear weapons; but as time went on it increasingly pulled between differentiating power production and weapons production goals. The civilian nuclear industry has its roots in Lenin's the state, starting in 1920, while its scope grew with his push for nuclear weapons in 1943. As the nuclear industry grew, "the bureaucracy that ran the electrification effort and the one that ran the nuclear weapons program would both undergo frequent changes, and precise responsibilities would shift repeatedly between them" (Schmid 2015, 41). Thus, the nuclear energy industry was trapped in the difficult position between the weapons complex and electricity industry, and in its early years, before its goals were more clearly articulated, its responsibility was split between the electrification bureau the Ministry of Energy and Electrification (*Minenergo*) and the nuclear weapons bureau the Ministry of Medium Machine Building (*Sredmash*). According to Sonia Schmid's (2015) account of the early years of the Soviet nuclear industry, "these competing bureaucracies created a volatile organizational environment and triggered ongoing tussles over authority and accountability; in addition, institutional inertia would sometimes affect the pace of the industry's progress" (41). The priorities for these bureaus frequently diverged, and responsibility for nuclear energy was formally divided away in subdivisions in 1966.

But even then, the enduring legacy of Sredmash left its mark on the Russian civilian nuclear energy program by preserving certain organizational behaviors rooted in the weaponization culture such as a heightened sense of responsibility, a clear system of executing decisions, the diligent selection and training of cadres, and a system of information exchange under conditions of secrecy (Schmid 2015, 43).

Early Nuclear Power Production Expansion and Chernobyl.

The world's first commercial nuclear power reactor was connected to the grid in 1954 in the "science city" of Obninsk (about 110kn southwest of Moscow) at APS-1 Obninsk.[55] The operation of this reactor represented a significant effort on behalf from the Soviet Union, and it provided a strong foundation from which the draw experience for future expansion of an electric power program furthered nuclear energy. Electricity production became an increasing problem for the Soviets, both in terms of scope of production and costs. Even though the country had vast natural resources such as, fossil fuels and other energy potentials, conversion to energy purposes was difficult as the extraction of coal, oil, and natural gas was largely concentrated in the harsh, remote, and expensive to operate environment of Siberia. As net energy costs rose in the Soviet Union in the 1960s and 1970s, a nuclear fueled power grid offered an increasingly promising future to offset these rising costs. In 1971, the government formally announced their decision to expand the country's nuclear power generating capacity. The Soviet nuclear power industry expanded

[55] The single Obninsk reactor produced electricity until 1959, after which it remained in operation until 2002 as a research and isotope production plant. At its inception, Obninsk produced 5000 kWe (or 5 MWe) at about enough to power 2,000 homes. In comparison, a typical nuclear power plant today produces about 1000 MWe, or enough to power 400,000 homes.

rapidly from there. Many plants still in operation in Russia today originate from this expansion (see figure below in next section). The nuclear power program increased rapidly to accommodate the need for electricity and rising costs, and seemed to hold favorable reception from the general populace as a modern, efficient form of energy generation. All this abruptly crashed in 1986 when the worst nuclear accident transpired at Chernobyl and sent major shocks through the Soviet nuclear industry.

For all of the promotion of a centralized, efficient bureaucracy dealing with the nuclear industry, the Chernobyl nuclear accident exposed all of the deficiencies of the bureaucratic structure and secretive nature of the nuclear industry. Chernobyl is the worst nuclear power accident in history taking into account cost, casualties, and classification on the International Nuclear Event Scale (which classified the disaster as a level 7 event, the highest).[56] It largely showed that the bureaucracy was ineffective to cope with risk and unpredictability. On April 26, 1986 in the Ukrainian city of Pripyat, Chernobyl power plant operators conducted systems tests that resulted in an unexpected power surge and spike in power output that ruptured the reactor vessel, and caused a series of explosions that led to a core reactor meltdown and resulting plume of radioactive fallout over large parts of Europe and the Soviet Union. In keeping with the culture of secretiveness, the Soviet government initially tried to keep news of the accident quiet. Eventually the accident became far too large to contain from its own public or international observers. The Soviet public that had previously been proud and supportive of a modern, industrialized nuclear future were suddenly skeptical not only of nuclear power, and also began to cast widespread suspicion of the

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[56] The only other INES level 7 event in history is the Fukushima accident.

Soviet government and the strength of its central organization. "The Chernobyl accident had a profound impact on Soviet society. Many commentators agree that the magnitude of the vent undermined the authority of the Communist Party" (Duke 2010, 32). Many have credited the Chernobyl disaster as serving the fatal blow to the USSR and directly contributing cause of Soviet collapse (see Weeks 2006). Chernobyl added momentum to the emancipation of the Soviet people through "this fundamentally new phenomenon—public disagreement between experts—and of the gradual opening of Soviet society, any reference to Chernobyl threatened to become a state-breaking device. Given the close connection between nuclear power and the state, every criticism of Chernobyl turned into criticism of the state" (Schmid 2015, 167.)

The Soviet state may not have survived the crushing weight of criticism in the aftermath of Chernobyl, and as such, it is shocking that the nuclear industry did not also succumb to mounting pressures. On the contrary, surprisingly and somewhat ironically, after the fall of the Soviet Union the nuclear power industry fared fairly well. Perhaps if the Chernobyl accident had happened in a different state where the nuclear industrialization and infrastructure was not as sufficiently developed, such an accident would have spelled certain doom for the nuclear power field. But in the new Russia, nuclear power was still seen as a productive means to escape mounting energy and economic concerns. Between the 1986 Chernobyl accident and mid-1990s, only one nuclear power station was commissioned in Russia.[57] However, in the 1990s the energy sector in Russia accrued massive debts and economic reforms following the collapse of the Soviet Union. This meant an acute shortage of funds for nuclear

[57] A four-unit plant at Balakovo, additionally with a third unit being added to the existing plant at Smolensk.

developments and a number of projects stalled. In spite of this, the nuclear industry found itself insulated from the most serious economic hardships through foreign aid, especially from the US. In the late 1990s Russia negotiated the exports of reactors to Iran, China and India and the country's domestic construction program was revived, as far as funds allowed. And as the years went by, output even progressed. “Not surprisingly, this performance led to the nuclear industry being hailed domestically as the answer to Russia’s energy problems. In 1992 the Russian nuclear power industry (Rosenergoatom) announced that reactors whose construction had been suspended in the aftermath of Chernobyl would be completed and new reactors brought online as well” (Duke 2010, 34). Thus, even the worst nuclear accident in history could not hold back the growth of the Russian nuclear industry.

6.1.2 *Status of the Nuclear Power Industry Prior to Fukushima.*

More recently, the Russian nuclear energy industry has focused on dedicated growth and keeping an attachment to its roots. “The centralized, bureaucratized, top-down Soviet system of management contributed to the momentum of the institutes and the technologies they designed and manufactured” (Josephson 2000, 3). Even with the dissolution of the Soviet Union and its economic and industrial decision making, the nuclear industry has still remained entrenched with the Soviet legacy and it “is by no means clear if more open, participatory institutions and procedures will emerge in the nuclear industries of CIS and non-CIS states of the former Soviet Union” However, “[t]he poor record of Soviet planning and administration in nuclear power and the resulting public opposition to this has legitimized and strengthened the cause for local sovereignty and local participation in decision-making” (Dodd 1994, 149). But, even with an increased drive to foster inclusiveness and transparency, the nuclear industry has remained largely attached to Soviet nuclear efforts.

The Russian nuclear power industry has gone forward through adopting a market driven economic model since the fall of communism. In particular, Russia has focused on achieving economic growth an expansion domestically and abroad. In contrast to the previous centralized organization, “there has not been a full return to technocratic rule: nuclear power managers in today’s Russia have to work very hard for policymakers’ support. In a long, difficult process, large parts of the nuclear industry have shifted to a market-economic model that includes several separate corporations” (Schmid 2015, 169). The Russian nuclear industry is today dominated by Rosatom, the state nuclear energy corporation (established in 2007) and regulatory body. In control of the nuclear energy and nuclear weapons complex, it is made up of several sub-bodies, although on the whole it is the only company in the world to offer the entire range of nuclear products and services. In addition, it is one of the few entities capable of supporting the entire fuel cycle from uranium mining, enrichment, power generation, reprocessing, and waste storage. Under Rosatom, is the Russian utility operating nuclear power plants, Rosenergoatom. Created in 1992 and reconstituted as a utility in 2001, it has ten branches supporting Russian civilian nuclear power. The corporate structure of these entities are still largely shrouded in secrecy, but their holdings and strategies indicate a strong commitment to expansion and economic viability of nuclear power in the future.

Through the Rosatom complex, the construction of nuclear units went through a revival by the dawn of the new millennium. Previously delayed units (such as, Rostov 1/Volgodonsk 1) started producing power and brought an increased morale to the Russian nuclear industry and boosting the nuclear grid to 21 GWe by 2001. In 2006, the Russian government further committed to nuclear power with dramatic aims of adding 2-3 GWe per year up to 2030, not only in Russia, but also around the world as growing demands for energy might open markets for Russian assistance in nuclear cooperation to a potential of some 300 GWe. The Russian nuclear industry added several more reactors domestically through the late 2000s and early 2010s.[58] Industry was doing well domestically and abroad, and significant investments were planned for continued expansion. By early in 2016, Rosatom claimed that Russia's GDP gained three roubles for every one rouble invested in building nuclear power plants domestically, as well as enhanced "socio-economic development of the country as a whole."

As can be seen from the table below, the Russian nuclear power industry is robust and poised to remain so for the long haul. As of mid-2016, Russia had 35 operating nuclear power reactors of various energy outputs and with various lifetime age and scheduled close dates. Most of the scheduled close dates showed that most Russian reactors have a significant lifetime still remaining on them. As Russia adds to its nuclear grid in the future, this added capacity will go toward expansion, rather than just replacement. Most reactors are licensed for life extension. Generally, Russian reactors were originally licensed for 30 years from first power, bringing many licenses up for review by 2000. Since then, Russia announced plans for lifetime extensions of 12 of the first-generation reactors and extension licenses are now granted between 15-25 years. Thus, Russia will need to significantly invest in refurbishment for its future.

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[58] Kalinin 3 in 2004, Rostov 2 in 2010 and Kalinin 4 in 2011.

Rosatom has been largely up to the challenge and is preparing to work with existing Russian infrastructure.[59] In July 2012, the Energy Ministry (Minenergo) announced plans to add 10 GWe nuclear to total 30.5 GWe producing 238 TWh/yr. (although this projection was later reduced to 28.26 GWe by 2019). Overall, the total investment into Russian energy infrastructure envisaged was RUR 8230 billion, including RUR 4950 billion on upgrading power plants, RUR 3280 billion on new grid capacity and RUR 1320 billion on nuclear.

Table 6.1: Russian Power Reactors in Operation[60]

Reactor	MWe net	First Power	Scheduled close
Balakovo 1	988	5/1986	2045
Balakovo 2	1028	1/1988	2033
Balakovo 3	988	4/1989	2034
Balakovo 4	988	12/1993	2023?
Beloyarsk 3	560	11/1981	2025
Beloyarsk 4	789	(2016)	
Bilibino 1-4	11	4/1974-1/1977	Dec 2018, Dec 2021
Kalinin 1	950	6/1985	2025?
Kalinin 2	950	3/1987	2032
Kalinin 3	988	11/2005	2034

[59] By the end of 2011, 15-year extensions had been achieved for 17 units totaling 9.8 GWe at Beloyarsk 3, Novovoronezh 3&4, Kursk 1&2, Kola-1-4, and Leningrad-1-4, as well as Bilibino 1-4.

[60] Source: World Nuclear Association, 2016

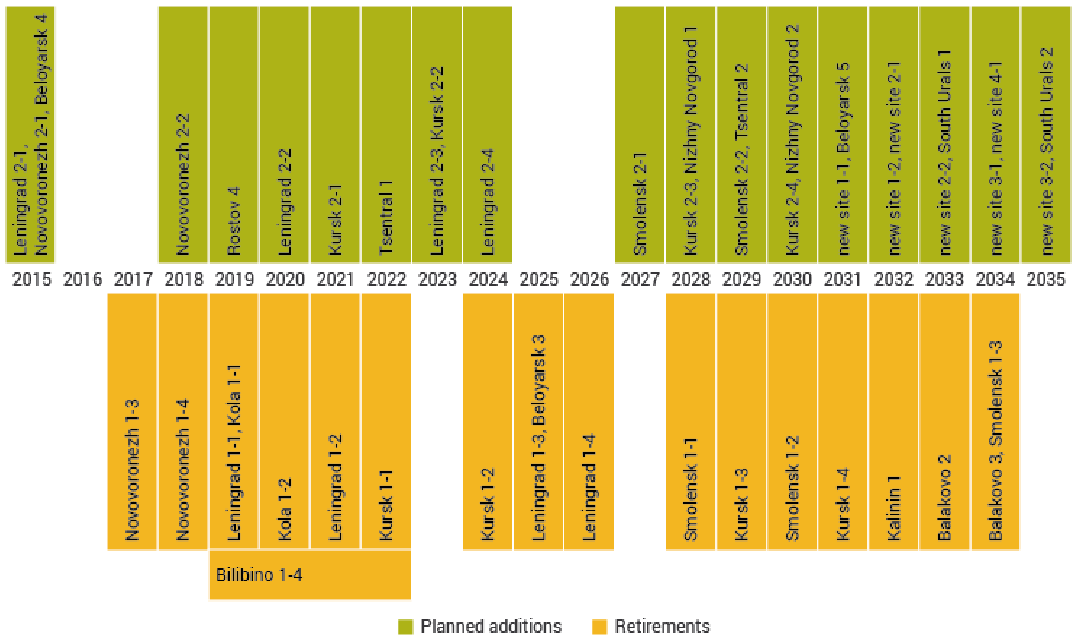
Kalinin 4	950	9/2012	2042
Kola 1	432	12/1973	2018 or 2033
Kola 2	411	2/1975	2020
Kola 3	411	12/1982	2026
Kola 4	411	12/1984	2039
Kursk 1	1020	10/1977	2022
Kursk 2	971	8/1979	2024
Kursk 3	971	3/1984	2029
Kursk 4	925	2/1986	2030
Leningrad 1	925	11/1974	2019
Leningrad 2	971	2/1976	2021
Leningrad 3	971	6/1980	2025
Leningrad 4	925	8/1981	2026
Novovoronezh 3	385	6/1972	2016?
Novovoronezh 4	385	3/1973	2032
Novovoronezh 5	950	2/1981	2035 potential
Smolensk 1	925	9/1983	2028
Smolensk 2	925	7/1985	2030
Smolensk 3	925	1/1990	2034
Rostov 1	990	3/2001	2030?
Rostov 2	990	10/2010	2040
Rostov 3	1011	9/2015	2045
Total: 35 – 26,053 MWe			

Overall, prior to the Fukushima accident, the nuclear industry in Russia fared quite well. In addition to expanding capacity, many had high hopes for investment into new types of nuclear technology, particular in the area of fast breeders and floating nuclear power plants. In February 2010, the government approved a federal target program designed to bring a new technology platform for the nuclear power industry based on fast reactors, which are safer and have a closed nuclear fuel cycle. Rosatom's long-term strategy up to 2050 (includes fast breeder reactors), termed the 'Proryv' (Breakthrough) Project, imagines nuclear providing 45-50% of electricity by that time, with the share rising to 70-80% by the end of the century. In the context of overall energy infrastructure, the Russian government approved plans in June 2010 for new generation of 173 GWe by 2030, of which 43.4 GWe would be from nuclear. This ambitious goal was later halved in January 2015, but the target still represented an ambitious outlook for nuclear energy in Russia.

6.1.3 *Nuclear Power After Fukushima.*

Russian nuclear policy after the Fukushima accident is characterized by three principles: adding additional nuclear capacity domestically, expanding exports of Russian reactors, technology, and assistance globally, and leading in nuclear innovation resources and industry. These defining trends have powered Russia very firmly into a strong commitment towards nuclear power in the future, and indicate a policy change that is more expansively pronuclear energy in the post-Fukushima period.

Figure 6.1: Russian Additions and Closures of Nuclear Power to 2035[61]



Planned Additions to Domestic Capacity.

On average, Russia is currently planning to add one large reactor per year through 2028, which will balance retiring capacity with new additions. After that, new additions will expand slightly beyond equilibrium. Of course, both estimates are taken without knowledge of if additional extensions of current licenses will be granted, so it is possible that capacity can be added beyond the expected balance. To fund the Russian expansion of nuclear capacity, the government undertook a $55 billion nuclear energy development program, with half of that being funded by the federal government (until the year 2015, when Rosatom will fund it solely from revenues).

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[61] Source: Rosatom, January 2015

This move is expected to raise the share of energy generated from nuclear and increase energy security.

Recently, Russian energy security faced a number of constraints because of domestic issues. After decades of stagnation, domestic demand for electricity has risen strongly since 2010. Despite holding some of the largest natural gas reserves in the world, Gazprom (Russian national natural gas company), has cut back on the amount directed for domestic consumption and focused more highly on exports abroad. Their strategy is politically and economically motivated, as the export of Russian natural gas goes to Western Europe at a much higher price, five times the profit than it would be supplying it for domestic electricity purposes. Furthermore, the export pipelines to Europe have given Russia a strategic political tool over European affairs (as evidenced by Russian actions in Ukraine and Crimea), and Russia likely would not want to lose that line of influence (27% of EU gas comes from Russia). These export opportunities have lowered the likelihood that natural gas resource would be directed to account for Russian energy demands. As such, Russia will have to look to other lines of generation to meet growing Russian demand for domestic energy, and as such, it appears nuclear power is increasingly which nuclear power necessary.

Exports of Russian Reactors.

Russia has made the export of nuclear goods and services major Russian policy and economic objectives. The nuclear entity Rosatom is the only full service nuclear corporation that can provide services on any area of the nuclear cycle, and as such, Russia wants to take full benefits of that advantage. They have significant ambitions for the export their nuclear expertise, particularly in terms of becoming one of the few sources of all-encompassing nuclear know-how and services.[62] The Federal Target Plan is intended to result in a 70% growth in exports of high technology equipment, works and services rendered by the Russian nuclear industry by 2020. Russia has plans for many foreign nuclear plants and often provides the financing necessary to achieve nuclear development, as evidenced in the table below.

Table 6.2: Export sales and prospects for Russian nuclear power plants (post-Soviet)[63]

Country	**Reactors**	**Est. Cost**	**Status (financing)**
Ukraine	Khmelnitski 2 & Rovno 4		operating
Iran	Bushehr 1		operating
China	Tianwan 1&2		operating
India	Kudankulam 1	$1.5 billion	operating since 2013
OPERATING: 6			
India	Kudankulam 2	$1.5 billion	Under construction
China	Tianwan 3&4	$4 billion	Under construction from Dec 2012
Belarus	Ostrovets 1&2	$10 billion	Loan organized for 90%, construction in 2013
CONSTRUCTION: 5			
India	Kudankulam 3&4	$5.8 million	Confirmed, loan organized for 85%, construction start 2014?
Banglades	Rooppur 1&2	$4 billion	Confirmed, loan organized for 90%, construction start 2015

[62] As of June 2016, Rosatom was actively marketing its services to Japan for contracting of Fukushima cleanup, by showing that it one of the few sources able to offer the full spectrum of nuclear services ("Rosatom, Japan discuss decommissioning of Fukushima installations," 6/6/2016)

[63] Source: World Nuclear Association, updated as of June 2016

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Turkey	Akkuyu 1-4	$25 billion	Confirmed, BOO, construction start 2016
Vietnam	Ninh Thuan 1, 1&2	$9 billion	Confirmed, loan organized for 85%, construction start 2017 or later
Finland	Hanhikivi 1	€6 billion	Contracted, Rosatom 34% equity, also arranging loan for 75% of capital cost, construction start 2018?
Iran	Bushehr 2&3		Construction contract Nov 2014, NIAEP-ASE, barter for oil or pay cash
Armenia	Metsamor 3	$5 billion	Contracted, loan for 50%
CONTRACTED: 14			
China	Tianwan 7&8		Planned
Vietnam	Ninh Thuan 1, 3&4		Planned
India	Kudankulam 5&6		Planned, framework agreement due early 2016
Hungary	Paks 5&6	€12.5 billion	Planned, loan organized for 80%
Slovakia	Bohunice V3		Planned, possible 51% Rosatom equity
Jordan	Al Amra	$10 billion	Planned, BOO, finance organized for 49.9%
Egypt	El Dabaa	$26 billion	Planned, state loan organized for 85%, repaid over 35 years from commissioning. Contract due early 2016.
ORDERED: 15			
India	Andra Pradesh		Negotiated in 2015
Bulgaria	Belene/Kozloduy 7		Cancelled, but may be revived
Ukraine	Khmelnitski	$4.9 million	Was due to commence construction 2015, 85% financed by loan, but contract rescinded by Ukraine in 2015
South Africa	Thyspunt		Broad agreement signed, no specifics, Russia offers finance, prefers BOO
Nigeria			Broad agreement signed, no specifics, Russia offers finance, BOO
Argentina	Atucha 5?		Broad agreement signed, no specifics, Russia offers finance, contract expected 2016.
Indonesia	Serpong		Concept design by OKBM Afrikantov
Algeria	?		Agreement signed, no specifics

Russia also has plans for an ambitious expansion in the foreign nuclear trade and demonstrated strength offering nuclear products and services for exports ranging from turnkey construction, fuel, and infrastructure development. From 2011 to 2015, Rosatom increased its orders for exports by 30%. The Ministry of Foreign Affairs is responsible for promoting Russian nuclear technologies abroad, including building up a system of Rosatom foreign representatives in Russian embassies. This demonstrates a significant vesture by the Russian government itself to see the success of the nuclear industry take hold worldwide. Rosatom's goal is to gain half of its total revenue from exported goods and services by 2030, and half of its reactor revenue from overseas projects in 2017. As of 2015 Rosatom's foreign portfolio of orders totaled $101.4 billion ($66 billion in reactors, $21.8 billion in contracted sales, and $13.6 billion to fuel assemblies and uranium), and export revenues in were $6.4 billion, up 20% from the previous year. It expects global construction from 2020 to average about 16 units a year. Russia backed much of this global expansion through competitive financing from Russia for nuclear construction in client countries, as these strategic priorities will, according to Rosatom, "contribute to the growth of the Russian economy and the expansion of Russia's presence in the global nuclear energy market." While the market has yet to reveal if this expansion of Russian nuclear presence abroad is sustainable,[64] Rosatom and Russian interests are clearly premised on its success abroad in the future.

[64] Several indicators recently have shown potential problems, in particular, that Russia may be overcommitted in its nuclear expansions abroad. For example, a project in Argentina backslid as local financing has pulled out and there is a new expectation that Rosatom will finance the project, and close attention is given to find signals of whether Rosatom is overextended in its ability to finance new nuclear reactors.

Developments of New Nuclear Technologies.

Russia is moving steadily forward with plans for development of new reactor technologies, with two of the biggest pushes coming from fast breeders and floating nuclear power plants. Fast breeder reactors involve a full recycling of fuel inputs, so that less fuel is required to be put into it. In 2012 the head of Rosatom announced a push to accelerate and test a full range of fast reactor technologies with associated fuel cycles operating by 2020, but to accomplish this Rosatom's R&D budget would need to be almost doubled by then. In 2010, the Russian government anticipated spending RUR 60 billion roubles on fast breeder development over the next ten years. Floating nuclear power plants are another major investment for Russia with expected costs at RUR 37 billion ($740 million) as of May 2015—with the first floating nuclear power plant expected to cost Rosenergoatom RUR 21.5 billion, and the second about RUR 18 billion. Floating nuclear power plants are low capacity, self-contained plants aboard floating hull boats that can be stationed in ports near remote areas and provide enough power or heat for up to city up to 200,000 people (and it can also be modified to function as a desalination facility). Russia currently projects that these floating nuclear power plants can be deployed to remote industrial areas of Siberia, where they would only need refueling every three years and have an expected lifetime of 40 years. According to Rosatom, 15 countries, including China, Indonesia, Malaysia, Algeria, Namibia, Cape Verde and Argentina, have demonstrated interest about floating nuclear power plants for their countries. These actions show that Russia is dedicated to the advancement of developing nuclear technologies both for internal and external use to open new markets for nuclear consumption.

6.1.4 *Overall Takeaways.*

The history of the Russian experience with nuclear power is characterized by a strong advancement of its industry and certain expectations about the purpose of its nuclear venture and marketability of its services. In each of the intervening variables, of advocacy, nuclear industrialization, dissent, and nuclear narrative, the Russian case has compelling evidence about their prospects for post-Fukushima policy.

On Advocacy Coalitions.

Throughout Russian history, pro-nuclear groups have held significant power. The nuclear industry has been tightly under the influence of state sponsorship since its inception and that support has promoted the expansion of the nuclear effort ever since. There is a small anti-nuclear movement in Russia, but their voice is largely drowned out by the massive nuclear lobby funded by Rosatom.

On Nuclear Industrialization and Infrastructure.

The Russian nuclear infrastructure developed into one of the largest and most widely supported ones in the world. From its beginnings in the nuclear weapons project, the nuclear energy field was a robustly supported industry by the government, and later propped up by an expansionist market potential.

On Public/Political Dissent.

Similar to advocacy, the impact of any dissenters to nuclear power, is crushed by the Russian nuclear complex. After the Fukushima accident, a poll by the BBC Globe Scan saw Russian “opposition to nuclear had risen from 65% (in 2005) to 80% with 43% opposing nuclear outright and 37% opposing new nuclear power plants, and just 9% being in favour” (Elliot 2012, 61). The government is able to counteract any impact from public opposition.

On a Nuclear Narrative.

Russia holds a strong pronuclear narrative of nuclear being a necessity for the country as a modern and technologically sophisticated nation and the industry brings great benefits to the Russian people. And, exporting nuclear technologies shows how "benevolent" Russia can be with its technology (in addition to bringing the promise of an influx of money).

In Conclusion.

The Russian nuclear industry is robust and primed for a strong nuclear outlook following Fukushima. The combination of strong pronuclear advocacy, strong nuclear industrialization and infrastructure, low public or political dissent, and strong benevolent nuclear narrative variables indicate a context where even after the Fukushima event opened a policy window following the accident that has evoked a pronuclear environment.

6.2 Part II: Germany

6.2.1 *Development of Nuclear Power in Germany.*

Unlike in Russia, where the nuclear narrative and buildup of the infrastructure was very positive from its beginning, nuclear technologies in Germany took a different path. Public opinion and narratives are largely negative about nuclear power in Germany. Nuclear weapons and nuclear energy are typically tightly wrapped together and the nascent industry of one can support the development growth of the other. Fearful of a rearmed state, Germany was not allowed to develop nuclear weapons per the Treaty of Brussels following World War II, but it was allowed to develop civilian nuclear capability for energy purposes. Nonetheless, the public felt lingering resentment over the status of nuclear weapons in the German military context. This resentment cast a shade against nuclear through the years, as nuclear weapons were largely seen as out of reach for Germany, either by the edicts of the end of the War, or by (as the Cold War progressed), and the NATO defense weapons in Germany over which they had no decisive control. Thus, Germans did not demonstrate favorability toward nuclear capabilities in the same way as other populous industrial, military countries. This skepticism toward nuclear carried over into prevailing attitudes and acceptance of nuclear in the energy portfolio.

Germany’s first research reactor began operating in 1957, and its first commercial nuclear reactor connected to the country's energy grid came online in 1969 at Obrigheim.[65] The Germany Atomic Energy Act of 1959 established a framework for regulating the approval of plants, construction, and operation. It also

[65] Ceased operations in 2005.

promoted nuclear energy by allowing for private investment in new reactors. The provisions of the Act provided for: privatization of the nuclear industry, limited and exempt liability for nuclear investors; and mandatory public hearings in the reactor approval process. In this setup, there is not a federal license agency (such as the NRC) but is moved to a Länder (or state-based) control of licenses where the reactor is to be installed. Responsibility for licensing the construction and operation of all nuclear facilities is shared between the federal and Länder governments. This creates something similar to close to a power of veto. Due to this diffused regulation of the nuclear industry in Germany, the character of anti-nuclear protests and groups developed distinctively regional characters (Joppke 1992). With the German nuclear industry not tightly connected to weaponization and clouded by secrecy and expediency it did in many other industrial powerhouses like the US and USSR, it developed its own institutional infrastructure that was largely managed by a group of policymakers and scientists, through the Economics Ministry, which was made up of official and interested parties from labor and industry. The development of nuclear energy technology in Germany was managed primarily by the Bundesministerium fuer Forschung and Technologie (the Federal Ministry of Research and Technology, or BMFT) and experts within the scientific community. This realm was tightly controlled under the purview of the technocrats, in its early Germany development "nuclear technology was largely ignored by the public and government officials monitoring and legislating it enjoyed relative anonymity and isolation" (McKee 2014, 75). Additionally, this structuring of the nuclear industry has been a defining characteristic of the Germany nuclear experience, as the decentralized reactor approval and licensing process has given a great opportunity to observe how public opinion and protest play a role in nuclear policy choice.

Public Opposition and Rise of the Green Party.

Public opposition to nuclear power in Germany eventually gained attention in the 1970s, and it has remained a significant and powerful part of its nuclear development since “Germany has a vibrant civil society that formed in reaction to the country’s wartime past, to its patriarchal and elitist decision-making structures, and to its wide spread environmental problems.” (Schreurs 2012, 32) The oil crisis in the 1970s brought an acute drive to finding ways to meet the energy supply gap with nuclear power and many nuclear plants in Germany were built during this era (none of them are still in operation today). Most German reactors were established in the 1970s and 1980s after pressure from chemical and electronic companies (Nelkin and Pollack 1980). The 1970s saw more widespread demonstrations against nuclear power plants, especially after large and violent demonstrations[66]. A particularly infamous incident happened at the construction site of a plant in Wyhl (in the southwestern state of Baden-Württemberg) in 1975, where 28,000 protesters successfully stopped the power station from being built.[67] A few years later, after news of the Three Mile Island accident in the US spread around the world, over 200,000 people came out to

[66] Violence was purported on both the ends of the civilians and the police, who were later criticized for the use of overly harsh tactics.

[67] The Whyl demonstrations were the first large antinuclear demonstrations in Germany, and gave inspiration to a budding antinuclear movement and civil effort against nuclear power plants. The antinuclear protests worked against the Whyl plant, and it was never built and eventually its site today is now a nature preserve (an ultimate victory for the environmental movement).

demonstrate against nuclear power in the streets of the industrial cities of Hannover and Bonn. On February 28, 1981 some 100,000 people faced off against 10,000 police officers to demonstrate against the construction of the Brokdorf nuclear plant on the North Sea.[68] Initially, demonstrations against nuclear power plants were rallies against and legal challenges about plans to build nuclear stations, but eventually they also grew to encompass a range of issues, such as, where the storage for radioactive waste processing and storage would be placed. Many of these issues confounded and brought the need for an organized, political party to address this opposition in the political arena. This was one of the driving factors behind the establishment of the Green Party in 1980 in Germany.

The Green Party of Germany largely owes its existence as an organized political party from a growing antinuclear movement and it has remained a primary opponent of nuclear power ever since as a legitimated participant in the political system. The antinuclear movement in Germany at its outset did not have a political sponsor, and the Green Party was formally founded as a political party to provide the movement with proper representation in parliament. In addition to their antinuclear goals the party focused on environmental rights (with anti-pollution laws and protection of natural spaces), human rights (with reproduction and immigrant rights), and anti-military weapons and NATO presence in Western Germany. They gained addition presence following the Chernobyl disaster in 1986. Regionally, the party found some success in state-level elections, and eventually received enough federal

[68] Protesters were unsuccessful in their goals of shuttling the plant. The plant began operations in October 1986 (several months after the Chernobyl disaster of April 1986) and is scheduled to go offline in 2018.

votes to gain seats in the lower house of the parliament in 1998. At this time the Greens formed a coalition with another party in the Parliament, the Social Democrats (SDU) under Gerard Schroder. However the two parties initially disagreed on the pursuance of nuclear power in Germany and dragged out negotiations for over a year before reaching a compromise to phase-out Germany's nuclear reactors by 2020. McKee (2014) describes what followed: "Though the nuclear phase-out was a policy gain for the Greens, this was hardly what anti-nuclear activists who had supported the party had envisioned after three decades of protest. Many left the party in frustration, arguing that the compromise was weak and left the door open for Conservatives to repeal it, which they formally did in 2010" (100). Thus, the popularity of the Green Party representation over time has shown some indication of the strength and standing of the antinuclear movement in Germany. The following table demonstrates the trends of the Green Party over time.

Table 6.3: Percentage of Votes for Green Party, 1980-2013

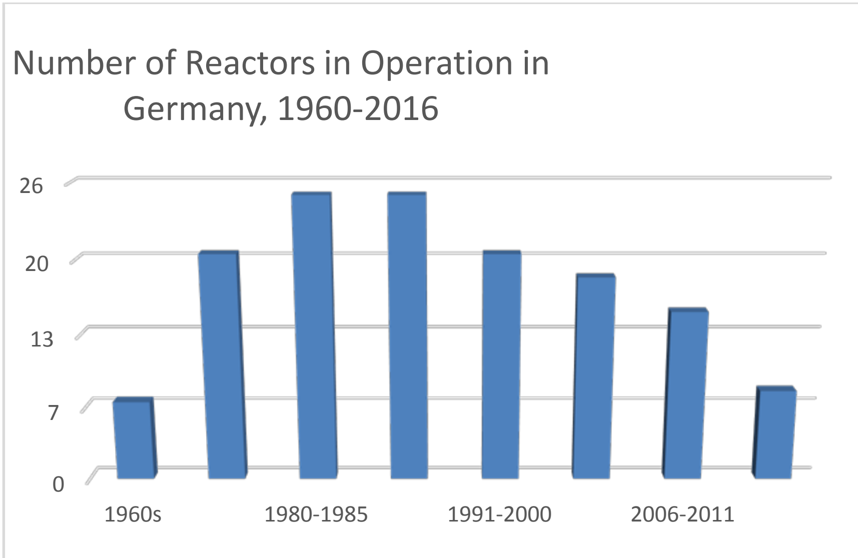
Year	Percentage of Party List Vote	# of Overall Seats Won
1980	1.5%	0/497
1983	5.6%	27/498
1987	8.3%	42/497
1990	5.0%	38/662
1994	7.3%	49/672
1998	6.7%	47/669
2002	8.6%	55/603
2005	8.1%	51/614
2009	10.7%	68/662
2013	8.4%	63/630

The Green Party saw a large spike in their electoral representation in the year immediately following the Chernobyl accident. In the 1990s, the Green Party formed a coalition with the SDU and amended the provisions of the Atomic Energy Act (as of then unchanged since 1959) to promote a structured phase-out of nuclear power which would grant the remaining reactors in operation an average lifespan of 32 years. The Social Democrat-Green Alliance held power in the Bundestand (German Parliament) until defeat by the Christian Democratic Union (CDU) led by Angel Merkel in 2005, which has been attributed with bringing another shift to the nuclear course (and eventually rescinding the phase-out in 2010). Through its rise, the Green Party brought with it an increased spotlight on antinuclear issues in the political arena.

6.2.1.1 *Green Party or Something Else?*

While the Green Party has been at the forefront of the antinuclear effort, its effects on longstanding antinuclear policy are debatable. What other factors may have been significant in German nuclear experience? On the one hand, the Green party represents a substantial factor of the antinuclear representation in the country. On the other hand, the antinuclear agenda of the Green Party only found a footing when they were in power with another coalition in parliament, and their commitment was weak with the SDP. Even when they were able to pass antinuclear policy, the ensuing compromise was weak and left vulnerable to be overturned by the next political party in power (which is eventually what happened when the Christian Democrat gained parliamentary majority next in 2005). As a result, Germany had a lot of back and forth policy movement on nuclear power throughout the 1990s and 2000s. Every reactor that would come online in Germany had already done so by 1990. The last finished and approved reactor, Neckarwestheim, began operations in 1989. The figure below charts the trajectory of Germany nuclear reactor operation across time.

Figure 6.2: Nuclear Reactors in Germany Across Time[69]



Since the 1990s, nuclear energy in Germany has been on the decline. This occurred for several reasons. First, many of the plans that came online in the 1960s finished their expected lifetimes and closed in the 1980s, on schedule, even though other power plants came online to take their place. Second, several reactors were closed after safety and structural concerns were found and the operating utility corporations found the repairs economically unfeasible to correct (notably the Mulheim-Karlich and Hamm-Uentrop reactors in 1988). Relatedly, German reunification in 1990 brought the closure of many East German nuclear reactors due to concerns about Soviet design and safety standards. Third, Germany did a poor job developing its nuclear infrastructure or advancing research and development as several advanced reactor designs in Germany were unsuccessful. Two fast breeder reactors

[69] Source: data compiled from Germany Energy Agency DENA

were built, but both were closed in 1991 without the larger ever having achieved criticality. The High Temperature Reactor THTR-300 at Hamm-Uentrop, under construction since 1970, was started in 1983, but was shut down in September 1989. Finally, fewer were brought online to replace those that were scheduled to close as other sources of energy became cheaper and utility companies stopped looking to invest in nuclear energy. The scheduled closures of nuclear reactors was a trend that compounded with the anti-nuclear policy by the parties in power in German politics in the late 1990s. Overall, the nuclear industry in Germany was beset by an antinuclear movement heralded by the Green Party, but it also faced other significant holdbacks from other sources.

6.2.2 *Status of the Nuclear Power Industry Prior to Fukushima.*

German nuclear policy has undergone a gradual shift away from nuclear energy. Especially since the 2000s, Germany has largely switched its concentration to renewables and other forms of energy generation. The pre-Fukushima period shows this trajectory in the nuclear realm well. Germany's energy goals are a mix of ensuring stability in the electricity supply (as a major producer and exporter of finished and technological goods) while also reducing greenhouse gas emissions. "Germany has some of the world's most ambitious greenhouse gas emission-reduction targets: a 40 percent reduction in carbon dioxide emissions from 1990 levels by 2020 and an 80 percent minimum reduction by 2050" (Schreurs 2012, 32). Nuclear power could help Germany meet those reduction goals and such a strategy was eventually viewed as a viable pathway. In 2010 the previous nuclear phase-out promoted by the Green Party/SDP was rescinded by the CDU-Liberal Free Democratic Party (FDP) and extensions were granted on licenses for existing nuclear power plants in exchange for taxes that would go to fund subsidies for renewable forms of energy such as wind and solar. Around this time, Germany was looking also to uphold its commitment to the Kyoto Protocol that compelled a reduction in CO2 emissions and the pursuit of clean energy sources.[70] The promotion of nuclear energy slowly crept back to the forefront. Even *Der Spiegel*, one of Germany's most widely read newspapers, ran a cover story entitled, "Atomkraft: Das Unheimliche Comeback" ("Nuclear Energy: Its Eerie Comeback"), and attributed the rise of nuclear power to the need to decrease CO2 emissions, the rising costs of conventional fossil fuels, and global political instability in energy exporters like Libya and Russia, which made the widely unpopular industry the "lesser of evils" for energy production (Sauga 2008).

Challenges from the Nuclear Industry and Political Arena.

In spite of public views of nuclear energy as a solution to carbon emissions, there were still significant holdbacks in the Germany's nuclear industry and political context. Germany had longstanding antinuclear sentiment and before Fukushima. In 2010, 64 percent of Germans surveyed reported being opposed or strongly opposed to building any new nuclear power plants.[71] This longstanding sentiment helped contribute to the existing advocacy against nuclear energy in Germany. Without the backing of a nuclear weapons infrastructure to support the nuclear power complex, the

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[70] Which was also largely prompted by German retraction from its coal industry (its most abundant naturally occurring resource).

[71] "Large Majorities in US and Largest European Countries Favor More Wind Farms and Subsidies for Biofuels, but Opinion is Split on Abandoning Nuclear Power." *PRNewswire.* October 13, 2010.

industrialization around nuclear concerns remained limited throughout much of Germany’s experience. Unlike Russia, Germany did not have large domestic supplies of uranium to draw from and have the ensuing business and lobby effort to sustain large scale nuclear activities. In East Germany from 1946 to 1990 only 220,000 tonnes of uranium (260,000 t U3O8) were mined (mostly in Saxony and East Thuringia, at a cost of substantial environmental damage). However, much of this went to Soviet weapons programs, and for fuel in Eastern Europe. After reunification, small amounts that resulted from decommissioning and mine closure activities were handled before the uranium business ceased. In Western Germany, a small mine, Ellweiler, operated from 1960-89. Now all uranium is imported, from Canada, Australia, Russia and elsewhere to a total of 3800 t/yr U. This lack of build up from the nuclear industry left Germany without a strong nuclear lobby for pronuclear advocacy making it all the more susceptible to antinuclear activism.

Additionally, the political context at the time was in a strange position over a nuclear future in Germany. The Green/SDP alliance was defeated and when a new government of the CDU/FDP coalition (led by the pronuclear Angela Merkel, a physical chemist by training, and one time Minister for the Environment and Nuclear Safety) took power in 2009, they committed to changing course on nuclear policy and rescinding the previously agreed upon phase-out policy for two purposes: the first being money, and the second on renewables goals. The government was keen to extend reactor lifetimes from an average of 32 years to 60 years, as the four nuclear power operating companies would reap an additional gross profit of €100 billion or more, and the government wanted to secure both a stake of these profits and the tax revenue.

After extended negotiations, a new agreement on nuclear policy was reached in September 2010 to grant license extensions for nuclear plants (8 years for pre-1980s reactors, and 14 years for later ones), at a price to operators of approximately €2.3 billion per year (in a €145 tax per gram of fissile uranium or plutonium fuel for six years), plus payment of €300 million per year in 2011 and 2012, and €200 million 2013-16, to go towards subsidizing renewables.[72] Additionally, outside of economic incentives, the CDU wanted the life of nuclear reactors to extend so that Germany would have an easier time meeting its committed reduction to greenhouse gases. Around the same time of the Fukushima accident, Germany embarked on a remarkable renewable energy push, "becoming a world leader in wind and solar power. Wind generation capacity expanded from less than 3 GW in 1998 to more than 27 GW in 2010. During the same period more than 17 GW of solar PV capacity was installed" (Elliot 2012, 32). Increasing renewable energy capacity and pairing it with a nuclear backbone that was a steady and already in place effort could stabilize the effort and help accomplish goals more easily. With all of these measures, the power shift in the German government showed an exposure to not only political maneuvering, but also the potential economic gains to be made by changing course on nuclear pursuance.

6.2.3 *Nuclear Power After Fukushima?*

The Fukushima accident happened at an awkward, but perhaps fortuitous moment for politics in Germany. After years of policy change back and forth on the country's nuclear phase-out, the government negotiated a fragile compromise to

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[72] However, utilities could reduce their contribution to renewables if safety upgrades to particular individual nuclear plants cost more than €500 million.

extend the operating lives of existing nuclear power plants. One of the most enduring aspects of the Fukushima accident on German nuclear power policy is that it consolidated the broadest imaginable public consensus for a phase-out (Glaser 2012). In March 2011 when Fukushima happened, the German government to immediately shutdown the seven oldest nuclear reactors in the country, placed a moratorium on extending the life of plants, and began an immediate review of the safety of all existing plants.

Figure 6.3: Nuclear Power Plants in Germany[73]

Existing nuclear plants are spread throughout Germany, and the resulting political fallout following the Fukushima Accident emerged from across the country.

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[73] Source: World Nuclear Association, as of 2016

There were major citizen protests organized against nuclear power in Berlin and other large cities and activists even formed a 27 mile chain in protest around the Neckarwestheim nuclear power plant. In the largest anti-nuclear demonstration ever held in Germany, some 250,000 people protested on March 26, 2011 (two weeks after Fukushima, and a day before major state level elections in Germany) under the slogan "heed Fukushima – shut off all nuclear plants." A German populace that was previously undecided on nuclear solidly moved against nuclear power. Within the year, public opposition to building new nuclear reactors in Germany rose from 73 to 90 percent according to a Globescan survey.[74]

Political Maneuvering, Antinuclear Sentiment, and the Push for Renewables.

In the immediate aftermath of the Fukushima accident, the Merkel government seemed unsure about how to respond, and in this vacuum a wave of existent antinuclear sentiments and coalitions emerged and gathered strength. In a surprise move, the government responded initially by placing a three month moratorium on nuclear energy following Fukushima, but even that was intended to be temporary and at the time was not indicative of a full impending phase-out policy. The nuclear phase-out became more imminent as public building to state level elections in German on March 27, 2011 showed prominent Green Party gains following the rise of antinuclear sentiment. The Green Party won significant gains in states that were previously strongholds for the CDU and Merkel. In Baden-Wurttemberg, a state under CDU

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[74] Globescan. 2011. "Opposition to Nuclear Energy Grows: Global Poll." November 25, 2011. http://www.globescan.com/news-and-analysis/press-releases/press-releases-2011/94-press-releases-2011/127-opposition-to-nuclear-energy-grows-global-poll.html. Accessed 6/15/2016.

control for 58 years, the Green Party won 24.5 percent of the vote, and the SPD another 21.3 percent, giving their coalition a majority of 47.3 percent against the CDU/FDP election results of 44.3 percent.[75] Likewise, in Rhine-Palatinate, where in the previous election the Green Party had failed to even achieve the 5 percent threshold for representation, the party secured 15.4 percent of the vote.[76] With these results and Green Party gains, Merkel and the CDU party realized the potential for loss of political power as public shifted its opinion on nuclear which brought an inescapable choice on nuclear policy on phase-out. When the measure to adopt a full permanent nuclear phase-out after the Fukushima accident came up for vote, a full 80 percent of parliamentarians voted for the bill in the Bundestag (federal parliament), and many of those not in favor like the Die Linke (Left Party) only objected because they wanted a faster exit and the measure's inclusion in the constitution. However, much of the swiftness of the action and was surprising in its accomplishment of a plan for shutdown of all German reactors by 2022.[77]

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[75] "CDU Suffers Historic Loss in Baden-Wurttemberg," *The Local*, March 28, 2011. http://www.thelocal.de/20110327/34003; Accessed 6/15/2016.

[76] "Poll, Voters Push Union From Nuclear Course," Der Spiegel, March 23, 2011. http://www.spiegel.de/politik/deutschland/umfrage-waehler-strafen-union-fuer-atomkurs-ab-a-752631.html; Accessed 6/15/2016.

[77] The shutdown and its immediateness has not left everyone happy, unsurprisingly. The nuclear utilities companies in Germany have been fighting since the moratorium was enacted, claiming a combined €875 million in damages, and seeking over €15 billion in additional compensation. Additionally, Swedish company Vattenfall is suing Germany for almost €4.7 billion at the International Centre for Settlement of Investment Disputes (ICSID) in New York (Appun 2015b).

Table 6.4: German Power Reactors in Operation[78]

Reactor	MWe (net)	First Power	Provisionally scheduled shutdown 2001	2010 agreed shutdown	March 2011 shutdown & May 2011 closure plan
Biblis A	1167	2/1975	2008	2016	shutdown
Neckarwestheim 1	785	12/1976	2009	2017	shutdown
Brunsbüttel	771	2/1977	2009	2018	shutdown
Biblis B	1240	1/1977	2011	2018	shutdown
Isar 1	878	3/1979	2011	2019	shutdown
Unterweser	1345	9/1979	2012	2020	shutdown
Phillipsburg 1	890	3/1980	2012	2026	shutdown
Krümmel	1260	3/1984	2016	2030	shutdown
Grafenrheinfeld	1275	6/1982	2014	2028	shutdown 2015
Total shut down (9) – 9611 MWe					
Gundremmingen B	1284	4/1984	2016	2030	end 2017
Gundremmingen C	1288	1/1985	2016	2030	2021
Grohnde	1360	2/1985	2017	2031	2021
Phillipsburg 2	1392	4/1985	2018	2032	2019
Brokdorf	1370	12/1986	2019	2033	2021
Isar 2	1400	4/1988	2020	2034	2022
Emsland	1329	6/1988	2021	2035	2022
Neckarwestheim 2	1305	4/1989	2022	2036	2022
Total operating (8) – 10,728 MWe					

[78] Source: World Nuclear Association, as of 2016

The hope for a nuclear renaissance in Germany was short lived after the Fukushima disaster, and it is unclear at present if the nuclear accident at Fukushima hastened an already doomed nuclear industry in Germany, or if the accident will have the same (lack of) sticking effect that Chernobyl had on German nuclear energy policy and political shifts will undo the policy change against nuclear power. Longstanding nuclear sentiment, cultivated largely by the Green Party, was present in Germany, but uncertainty remains if that sentiment would have been capitalized upon if it had not been for the timing of the accident so close to the election that brought a big win for the Green Party. Polls show that the majority of the German public believes that the nuclear phase-out decision wasn't about fears of nuclear safety or responsiveness to public opinion, but rather, was a calculated political maneuver by Angela Merkel and the CDU to respond to electoral gains by the Green Party in a stronghold state that might spread and amount to CDU losses throughout Germany (McKee 2014).

Moreover, when the Merkel government realized that nuclear energy might not be able to provide the way forward in the expansion of renewables and lowering CO2 emissions, it decided to adopt a new strategy for abandoning nuclear power. Only a few short months after the accident, by May 2011, the leading political coalition had announced a phase-out of Germany's existing reactors by 2022. Germany pursued a policy of "Energiewende"[79] or energy turn, an initiative encouraging a switch from nuclear power to more renewables sources like wind, solar, and hydropower. The goals of the plan are to reduce CO2 emissions 80-95 percent by 2050 (compared to 1990 levels) and ensure renewable sources account for 60% of energy generation by

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[79] A nationwide program financed largely by private electric consumers in Germany, who already pay the highest energy rates in the European Union outside of the Dutch.

2050. In doing so, Germany rolled out massive subsidies to renewable energy producers. These subsidies increasingly reveal themselves to be unsustainable and received worldwide criticism. In late 2015, a special report of *the Economist*[80] stated that:

> Germany has made unusually big mistakes. Handing out enormous long-term subsidies to solar farms was unwise; abolishing nuclear power so quickly is crazy. It has also been unlucky. The price of globally traded hard coal has dropped in the past few years, partly because shale-gas-rich America is exporting so much. But Germany's biggest error is one commonly committed by countries that are trying to move away from fossil fuels and towards renewables. It is to ignore the fact that wind and solar power impose costs on the entire energy system, which go up more than proportionately as they add more.

While ambitious in its goal of carbon reductions, the ensuing result on the power industry has not been free of controversy either. But the German government has adopted an "all in" approach to investment in a future that is heavily reliant upon renewables generation, without nuclear power. So far the transition has been rough for Germany, and time will tell if the post-Fukushima policy change on nuclear power was the best choice.

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[80] "Hot and Bothered: Special Report on Climate Change," *The Economist.* November 28, 2015. http://media.economist.com/sites/default/files/sponsorships/[ALL28]/20151128_Climate.pdf; accessed 6/26/16.

6.2.4 *Overall Takeaways.*

Since the 1970s, the nuclear industry in Germany has faced significant public and political opposition, especially through the emerging Green Party. Three factors that McKee (2014) identifies as crucial to understanding the development of the Germany nuclear energy industry are 1) the decentralized reactor approval and licensing process and how public opinion and protest have played a role in these processes 2) the ebb and flow of nuclear pursuance over time, as its political context through party groups has not been unified across time on nuclear energy, and 3) the post-Fukushima period has been highly reactionary to the incident. These characteristics make it disposed to antinuclear policy change after the policy window opening and the combination of intervening variables come together.

On Advocacy.

The German public, from the beginning of their nuclear experience, was largely inclined toward antinuclear sentiment. From the lack of a supporting weapons infrastructure that could lobby on behalf on pronuclear goals, to the inclusion of a major political party with a primary goal of getting rid of nuclear power, to the diffused nature of regional governance of nuclear power that enabled more local advocacy groups legitimate inclusion in decision-making, Germany had advocacy groups in place largely against the promotion of nuclear power, and that experience proved instrumental in the opening of the post-Fukushima policy window in having a high level of antinuclear advocacy and a low level of pronuclear advocacy.

On Nuclear Industrialization.

Germany lacked a significant nuclear infrastructure, and thus did not have the weight of a pre-exisiting industry to continue its promotion. Germany is reliant upon outside suppliers for uranium to feed its power reactors, and research and development into advanced nuclear technologies failed to gather necessary support. Germany had a low level of nuclear industrialization or infrastructure.

On Public/Political Dissent.

Deep seated distrust of nuclear power has been present in its populace since its nascent experience with nuclear power, and Germany has a long history of massive demonstrations against nuclear power. As a politically free society, public discourse is not repressed and so antinuclear sentiments were not hidden by the government. And, within Germany's main governing bodies, the Green Party offered additional representation of dissenting opinion on nuclear power. Germany had a high opportunity for public and political dissent on its nuclear power program, including viewpoints that may have been contradictory to government policy.

On Nuclear Narrative.

As German's have been largely skeptical of nuclear power, the prevailing narrative towards nuclear has been one of environmental destruction, unnecessary risk, and health concerns. Through highly public demonstrations and political dialogues, the face of nuclear in Germany has received a lot of critical portrayals and there have been high profile attempts to get rid of nuclear in Germany, which has left a lasting impression and build up towards nuclear policy. The narrative in Germany has been antinuclear and welcoming of alternatives to nuclear policy pursuance.

In Conclusion.

The German nuclear experience brought high antinuclear advocacy, low nuclear industrialization and infrastructure, a high opportunity for public and political dissent, and a prevailing nuclear narrative that was antinuclear, all creating a recipe for antinuclear policy change following the Fukushima accident.

6.3 Part III: Canada

6.3.1 *Development of Nuclear Power in Canada.*

In almost all aspects, the Canadian experience with nuclear power represents a middle ground between the Russian and German cases. Unlike in Russia, where the industry was fiercely entrenched in nuclear capability from the development of nuclear weapons, or Germany, where skepticism always cast a shadow over the nuclear arena and the country was forbidden from having anything to do with weapons technology, Canada does not have a supporting nuclear weapons infrastructure. However, they were on the ground floor of nuclear weapons development and have largely been caught in the middle between contending nuclear coalitions and narratives about the impact of a nuclear technology. Canada could have developed nuclear weapons, did not. “Canada is one of the world’s leading countries in nuclear technology. Since 1946 this has included the capability to develop nuclear weapons; but Canada has chosen not to do so. In fact, a weapons program for Canada has never been seriously considered. All Canadians should take pride in this fact” (Tammemagi and Jackson 2009, 13-4). Canada’s experience with nuclear technology dates back to the Manhattan project. It was one of the major international partners establishing the proper techniques and materials to sustain a nuclear reaction. Canada has long valued its standing in the world as an expert developer of nuclear technological expertise. As stated by C.J. Mackenzie, former president of the National Research council during World War II, Canada’s participation in the Manhattan project along with the United States and Great Britain allowed it to get in “on the ground floor of a great technological process for the first time in Canadian history” (Bothwell 1988, 22). After the wartime imperative for nuclear capability, there was no question that Canada would continue to drive to exploit the atom and "were determined not to lose the unique technological advantage that it had acquired during the war" (Bratt 2012, 112). Canada's nuclear legacy is largely derived from this prestige of being an active participant in sophisticated nuclear technology.

The CANDU Reactor.

The CANDU reactor is considered one of Canada's greatest engineering accomplishments and represents a crowning source of public pride of the Canadian nuclear industry. In 1987, the Engineering Institute of Canada ranked the CANDU reactor as one of Canada's top ten engineering achievements of the previous 100 years.[81] Most nuclear reactors around the world require an intensive enrichment process to develop sufficiently enriched uranium to sustain a nuclear reaction.[82] Canada started experimenting with a reactor design that could use heavy water and uranium that would not require the intensive and expensive enrichment of most types of nuclear reactors, which was a significant breakthrough in technology. "In Canada,

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[81] Additionally, the statement made about the CANDU reactor when the award was given highlights the significant impact the CANDU had not only on the power industry but in split off areas: "Perhaps the greatest challenge posed by CANDU was the necessity of adhering to extremely high quality standards in every aspect of the project—in design, manufacture of components, construction and maintenance and operation. This resulted in advances and activity in numerous other related fields. Perhaps best known are the medical applications, such as cobalt therapy machines for cancer treatment. Other spinoffs from the nuclear program include automatic computerized control systems, simulator models, remote handling techniques, and fundamental advances in areas such as metallurgy and chemistry."

[82] 99.3% of the uranium found in nature is the U238 is the isotope. But the U235 isotope is needed to sustain the nuclear reaction, so the naturally occurring uranium has to be refined to achieve a level of 3-20 percent U235 enrichment to be able to power a conventional nuclear power station.

all nuclear reactors are CANDU (Canadian Deuterium Uranium) reactors. Unlike virtually all reactors everywhere else in the world, the uranium in the fuel they use is not enriched; the ratio of the various uranium isotopes is the same as the ones that occur naturally" (Brook 1997, 118). The advantage of using heavy water (deuterium oxide) as a moderator and coolant are savings in fuel cost (because the uranium does not have to go through the intensive enrichment process), an increase of levels of safety features, and a reduction of power downtime as it can be refueled while in operation and does not need to be refueled as often as conventional reactors. But, any potential savings can be offset by the costs imposed by producing expensive heavy water. By the early 1950s Canada's nuclear efforts were directed towards designing a reactor that could be used for electricity generation using this CANDU model. Eventually the Canadian nuclear industry was interested in exporting their model of reactors abroad.[83] As a result, the domestic Canadian nuclear companies developed a strong political and economic influence over advocacy of nuclear power policy, both at home and abroad.

Contending Pro and Anti-Nuclear Coalitions.

According to Bratt (2012), advocacy and the surrounding narrative of nuclear power in Canada is split between two different coalitions that take either a pro or antinuclear stance. On the one hand, the pro-nuclear coalition is made up of Atomic

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[83] CANDU reactors can now be found today in Pakistan, Argentina, South Korea, Romania, China, and India (although Canada suspended its nuclear dealing with India in 1974 after the country detonated a nuclear weapon; India today has installed "CANDU derivatives" based on the design proponents but not actually in cooperation with Canada).

Energy of Canada Limited (AECL),[84] the component suppliers, provincial utilities, business associations like the Canadian Nuclear Association (CNA), unions of nuclear workers, and the scientific community. On the other hand, in opposition, the anti-nuclear coalition is largely made up of environmental groups like the Sierra Club and the Pembina Institute and specific interest groups like the Canadian Coalition for Nuclear Responsibility (CCN). Accordingly, “the pro-nuclear coalition wants government to increase the size and scope of the nuclear sector, while the anti-nuclear coalition seeks to roll back and eventually phase it out. The composition of these two coalitions has been relatively stable for decades” (Bratt 2012, 6). The pronuclear side established itself at the outset of the industry’s inception, but since the 1970s, the antinuclear coalition has become a growing influence. Like many places around the world, the antinuclear movement started in the 1950s, but was still entrenched within a larger peace movement (initially primarily concerned with nuclear weapons). By the 1970s it took a turn toward the opposition of nuclear energy, at which point the movement gained momentum and combined with the country's emerging environmental movement. Even with expansion, the antinuclear coalition in Canada has largely struggled against the larger populated, better funded, and more visible

[84] AECL is also the designer, engineer, distributor, patent holder, and marketer of the CANDU nuclear reactor and provides a range of nuclear services “from R&D support, construction management, design, and engineering to specialized technology, waste management and decommissioning in support of CANDU reactor products.” This is also important to understand in the context of the strength of the pro-nuclear side of the Canadian nuclear industry, because significant investment and effort is put into the development and export of CANDU reactor technology both within Canada and around the world. Outside of Canadian headquarter offices, AECL maintains international offices all the countries where it has either sold a CANDU or hopes to sell one, including Argentina, China, South Korea, Romania, and the United States.

pronuclear, business-centered coalition. For example, the Pembia Institute (anti-nuclear) has around 50 staff members and revenue of about 4.3 million, but AECEL (pro-nuclear) has over 4,700 employees and revenue and funding of over $900 million (Bratt 2012, 47). The pronuclear coalition has historically been the stronger of the two sides; however, recently there is consideration that the antinuclear crowd is gaining traction as the nuclear sector in Canada as has stagnated during an economic recession.

6.3.2 *Status of the Nuclear Power Industry Prior to Fukushima.*

Despite the fact that no new Canadian nuclear power plants have come online since the 1990s and the economic pullback, the industry itself is an economic engine. Nuclear power averages about 16% of Canada's overall energy make up, and in Ontario (the most populous Canadian province) it makes up 60% of energy production. From 1952 through 2006 the government of Canada invested over C$13 billion dollars into the nuclear program through AECL. The return on the investment has added more than C$160 billion to the Canadian GDP through power production, research and development, CANDU exports, uranium, medical radioisotopes and professional services, according to AECL. According to Doern, Dorman, and Morrison (2001) there are four key values that have driven forward Canadian nuclear policy and that while "shared, disputed, and debated by governments and stakeholders": (1) a belief that nuclear energy is an important source of energy; (2) an understanding that it is a key element of Canada's scientific and technological capacity and a source of considerable employment, especially in Ontario; (3) a deeply embedded concern about the safety of nuclear reactors; and (4) core values, which are fundamentally global, about ensuring that nuclear materials are not diverted to military use and that nuclear waste materials are convincingly made safe by long-term storage. Prior to the Fukushima accident, these principles loomed long over the Canadian nuclear industry as it was viewed as a significant technology and energy generation capacity, but with deep concerns about safety and control of nuclear waste. Thus, there was mostly a strong belief in the potential of nuclear power, with areas of skepticism.

Political and Geographic Structure.

Canada has a progressive, transparent political system, which over the years has caused a split on nuclear power. "Canada, with its parliamentary structure, is not usually seen as an open political system. However, most decisions concerning nuclear energy require public hearing, (for the licensing of nuclear reactors, opening new uranium mines, selecting waste disposal sites, and so on). This provides a high degree of political openness" (Bratt 2012, 9). In Canada, most of the decisions in the nuclear sector are made by the political executive, the prime minister, and/or cabinet. As the Canadian system operates under federalism, much decision making happens at the provincial level, and thus some coordination must occur between the two levels of government. Canadian energy polices have evolved to reflect individual provincial or regional strengths. Therefore, individual provinces played a significant role in the development of nuclear power within their respective province. For example, Ontario has been highly favorable to nuclear power and its development, and most nuclear plants in Canada are located in that province. Public opinion rates change depending on which part of the country one visits, with ranges of favorability from a high of 54% in Ontario to a low of 12% in Quebec. Most plants are located in the east of the country in New Brunswick and Quebec (where some of the backlash against nuclear energy has been the most felt), in addition to Ontario. By contrast, British Columbia has a strict no nuclear policy and has prohibited the construction of any nuclear power stations.

Figure 6.4: Canadian Uranium and Nuclear Power Plant Sites[85]

Even outside of nuclear reactors, the impact of the industry is felt across the country, as the figure above shows. The heavy concentration of uranium mining in Saskatchewan has pulled it into the nuclear industry, even though there are no nuclear power plants operating in that province.

Despite the far reach and widespread presence in many Canadian citizens' lives, nuclear policy often flies below the radar of political consciousness. The state of

[85] Source: World Nuclear Association, updated March 2016

Canada's nuclear industry is not necessarily well known to Canadians or understood by Canadian voters and citizens, in part because nuclear policy only receives intermittent political and media attention. Indeed, the last burst of focused analytical attention in Canada was about twenty years ago (Doern and Morrison 1980). Furthermore, nuclear power in Canada is complex and wrapped up in other policy contexts, or "put another way, nuclear policy cannot be divorced from industrial policy, science and technology policy, foreign policy, energy policy, environmental policy, and global security concerns about nuclear proliferation" (Doern, Dorman, and Morrison 2001, 4). It is an area that is so embedded in other aspects, it is hard to single out just the nuclear realm for adjustment without also impacting the other policy spectrums that are related to it. Therefore, nuclear power in Canada follows a somewhat entrenched mechanism that has increasingly become difficult to understand comprehensively by both the public and policymakers, which means stakeholders can be swayed by both the pro and antinuclear coalitions.

6.3.3 *Nuclear Power After Fukushima?*

In the aftermath of the Fukushima accident, the Canadian experience of nuclear power remained unchanged. In terms of public opposition to nuclear power, there was hardly any change to following the Fukushima disaster. According to the Canadian Nuclear Association,[86] prior to the accident, 38% of Canadians were in

[86] Innovative Research Group. 2012. "National Nuclear Attitudes Survey," *Canadian Nuclear Association.* July 9th, 2012. https://www.cna.ca/wp-content/uploads/2014/05/2012-Public-Opinion-Research-%E2%80%93-National-Nuclear-Attitude-Survey.pdf; Accessed 7/1/2016.

favor of nuclear power while 56% opposed it. In 2012, after the accident, 37% were in favor and 53% were opposed to nuclear power, and the population that neither supports nor opposes nuclear power grew to 9%. Overall, Canadians reported a high degree of saliency of the Fukushima accident, as 70% of Canadians polled reported that they had followed the Fukushima Daiichi Power Disaster at least somewhat closely. Even after this close association with the dangers of nuclear power, the accident did not change much of the domestic perception of nuclear power for Canadians as the level of opposition to nuclear was consistent.

The economic indicators of the Canadian nuclear industry have also remained robust, showing a strong association to pronuclear advocacy and industrialization. According to a study by the Canadian Energy Research Institute, Canada's nuclear reactors contribute C$6.6 billion per year to GDP and create C$1.5 billion in government revenue through federal and provincial taxes. Additionally, exports have always been a major factor in Canada's nuclear policies (Morrison and Wonder 1979), and Canada generates some $1.2 billion in exports, particularly of CANDU technology and uranium. In terms of the size of the nuclear power industry, across over 150 firms it employs 21,000 directly, 10,000 indirectly as contractors, and is responsible for another 40,000 jobs. Several Canadian provinces have committed to keeping nuclear power generation as a significant part of their energy make up. Ontario's 2013 Long-Term Energy Plan commits to keeping nuclear power at approximately 50% of the province's electricity supply while New Brunswick's Energy Blueprint expects nuclear to continue to contribute 35%. Of the domestic nuclear reactors in Canada, the lifetime of the remaining on most plants does not present an immediate need to replace the reactors with new facilities, so the Canadian nuclear plan is durable in maintaining the status quo of operation.

Table 6.5: Canadian Reactors in Operation

Reactor	MWe net	First Power	Scheduled Closure
Pickering A1	515	1971/2005	2022
Pickering A4	515	1972/2003	2018
Pickering B5	516	1982	2018
Pickering B6	516	1983	2019
Pickering B7	516	1984	2018
Pickering B8	516	1986	2018
Bruce A1	750	1977/2012	2035
Bruce A2	750	1976/2012	2035
Bruce A3	750	1977/2004	2036
Bruce A4	750	1978/2003	2036
Bruce B5	825	1984	
Bruce B6	825	1984	
Bruce B7	825	1986	
Bruce B8	825	1987	
Darlington 1	881	1990	2025
Darlington 2	881	1990	2025
Darlington 3	881	1992	2025
Darlington 4	881	1993	2025
Point Lepreau 1	635	1982/2012	2037
Total operating (19) – 13,553 MWe			

The Future of Coalition Balance.

According to a very thorough examination of the Canadian nuclear industry by Duane Bratt (2012), the pro- and anti-nuclear coalitions in Canada have developed deeply held policy beliefs over which they seek public attention and policy promotion, and these frames have been contested in the aftermath of the Fukushima accident and have brought a stalemate to the nuclear industry. Over time, the lines in Canada have become clearly drawn amongst those in advocacy and industry, and each side has developed a framework of policy beliefs that are used to shape an ongoing narrative about the benefits or disadvantages of nuclear power. These frameworks are actively used by the groups to promote their specific set of normative ideals and policy goals, as noted in the table below.

Table 6.6: Canadian Nuclear Sector and Policy Narratives[87]

	Pro-Nuclear Coalition	Anti-Nuclear Coalition
Actors	• Nuclear Industry (CNS, AECL, Bruce Power, etc) • Nuclear Unions (CNWC) • Nuclear Scientists (CNS) • Officials of the Department(s) of Energy	• Anti-nuclear groups (CCNR, CNP) • Environmental organizations (Pembina, Sierra Club) • Officials of the Department(s) of Environment
Policy Beliefs	• Nuclear energy is a safe and economical form of electricity • Since nuclear energy does not emit greenhouse gases, it can address the problem of climate change • Nuclear energy contributes to the Canadian economy through jobs and GDP • Nuclear energy has resulted in technological spin-offs • The CANDU is prestigious to Canada • Nuclear energy does not lead to weapons proliferation • Nuclear waste issue has been exaggerated; it is being managed • Renewables energy has significant flaws	• Nuclear reactors are unsafe (Chernobyl, Fukushima) • The entire fuel cycle creates radiation, which causes cancer • Reactors produce nuclear waste that lasts for hundreds of thousands of years • Nuclear energy is not a solution to climate change, and instead resources should be devoted to conservation and renewable energy sources • There is a clear link between civilian nuclear energy and military nuclear bombs • Nuclear energy is uneconomical and is highly subsidized by the government

Largely, these policy beliefs show the ways in which different coalitions process and create analytic attempts (or narratives) to manage risk around nuclear energy. As Durant and Fuji Johnson (2009), longstanding critics of Canadian nuclear energy particularly related to nuclear waste issues, explain "where risks are brought to the front stage by dominant actors, this can be a subtle means of promoting a narrowly

[87] Source adopted from Bratt 2012, page 25

instrumentalist and pragmatic view of the issue in dispute" (6). These groups use their narrow viewpoint of the issue of nuclear power generation to best suit their purposes. Their belief systems are fundamentally opposed, especially when exploring how they consider risk. Each side's policy goals are embedded within a concept about how the associated risks of nuclear power can be received by the public and its benefit to society. In the pronuclear coalition, the risk of nuclear power is technologically determined, backed by statistically calculated hazards; the industry has made technologically and economically advantageous decisions on risk. Meanwhile, the antinuclear concept of risk is socially constructed and emphasizes a need for greater inclusion than just the government supported industry in risk decision making. The conflict between the two sides is exacerbated by the tendency to demonize the other side as less trustworthy with malicious intentions. These two coalitions and their outlooks have dominated the Canadian nuclear experience, and in post-Fukushima era they have continued to equally promote their policy beliefs and associated goals which continues to shape the dialogue on nuclear power in Canada. The approach to nuclear power is divided, and this representation of each advocacy has largely brought a standoff to nuclear issues as promoted a maintenance of the status quo policy.

6.3.4 *Overall Takeaways.*

The nuclear industry in Canada has maintained a balance between pro and antinuclear factions. Over time, the nuclear industry developed into a well-organized system that is focused not only on the promotion of nuclear capabilities domestically but also abroad. At the same time, there remains well-established and active opponents to nuclear power. Both critics and proponents are well represented in the dialogue around nuclear energy. In the policy window opening from the Fukushima accident, Canada has largely been able to maintain a status quo stance on nuclear policy in light of the weight behind each nuclear coalition.

On Advocacy.

There are many in Canada that would like nothing more than to do away with nuclear power altogether. But there are also many that support the propagation of nuclear as a dependable and sustainable energy source for Canada. Each side is well developed and has considerable resources and forums for public exposition. In this case, Canada evidences a strong case for both strong antinuclear advocacy and strong pronuclear advocacy groups, and their efforts counteract each other and bring a balance to political decisions.

On Nuclear Industrialization.

The Canadian nuclear industry is significantly advanced. In spite of lacking a nuclear weapons infrastructure to support its energy side, the nuclear power industry represents a substantial venture in economic means and manpower, and at both federal and provincial levels has enjoyed political backing (even though some provinces have been largely uninvolved with nuclear power). Canada has one of the largest uranium miners in the world, and is able to export much of their supply abroad. Additionally, much of the nuclear industry is geared toward exporting nuclear reactors technologies, through CANDU, as a product of Canada, which also brings a continued investment in a nuclear infrastructure.

On Public/Political Dissent.

Canada is a politically free and open country, and so there is a high degree of opportunity to express public dissent against nuclear policy. While some areas of

Canada have taken to political means to express policy against nuclear power (like British Columbia instituting a ban against nuclear in that province), opposition to nuclear power has not removed it from operating. While opposition to nuclear power has consistently remained around half of Canadians, that has not changed the course of nuclear policy, even when a focusing event occurs.

On Nuclear Narrative.

The nuclear narrative in Canada has not been firmly entrenched in a specific orientation towards nuclear power; instead, it has been constantly challenged but both pro- and antinuclear coalitions. One side represents nuclear as a technologically sophisticated export that Canadians should be proud to be a part of, while the other paints it as environmentally and economically destructive. Each side has a place at the table in nuclear decision making table.

Overall Conclusions.

Canada has both high antinuclear and pronuclear advocacy, high nuclear industrialization and infrastructure, a high opportunity for public and political dissent, and a nuclear narrative that was split between supporting and opposing nuclear power. This combination of variables bring together conditions that allow for a continuance of nuclear policy that resulted in no substantive change on policy following the Fukushima accident. The nuclear industry in Canada is strong, but the government is stuck in the middle of pro and antinuclear groups and as such, any sort of significant change on nuclear policy is unlikely.

6.4 Part IV: Overall Comparative Case Conclusions

The goal of this chapter was to investigate three country case studies to better understand the dynamics of policy change on nuclear power following the Fukushima accident. From that assessment, certain conditions were expected to promote different policy change outcomes: the strength and characterization of nuclear advocacy, the level of development of the nuclear industry and infrastructure, the opportunity to express a dissenting opinion on nuclear power policy, and the prevailing narrative around nuclear power within the country. Each case showed a different experience those conditions, and a consequentially different outcome on policy change on nuclear power. Before turning to a discussion of each of these conditions and comparing them in each case, there are some associated conclusions from the analysis to consider first:

- A state's experience with nuclear weapons helps reveal its preference towards nuclear energy capabilities. If a weaponization capacity is present, then the prospects for a strong nuclear industrialization and positive nuclear narrative are more likely to persist because there is a reinforcing aspect on the overall nuclear production. Russia struggled to separate the nuclear power sector from the nuclear weapons complex. The narrative of nuclear was positive as a prestigious and necessary component for the country. Contrarily, in Germany there was always a ban on nuclear weapons, and the populace grew to be highly skeptical of nuclear as a result and established a developed antinuclear movement. Whereas Canada was on the ground floor of nuclear weapons but did not develop them (even though they've always had the capacity to do so at an instant), and instead promoted an endearing "usefulness" narrative of nuclear, from the technological, prestige, and economic motivations of nuclear power generation, even though there is a strong opposition group to nuclear power.

- The structuring of the nuclear industry itself brings an opportunity for how dissent is processed. Centralized nuclear regulation and infrastructure systems are more likely to continue with their plans for nuclear because they are more insulated and have an interest in the promotion of the nuclear. Those with a decentralized approval and loosely industrialized nuclear complex are more prone to citizen influence and pullback from investment. Russia has always had a very strong central authority on nuclear, with heavy state involvement into the industry. Germany maintained a regional authority over nuclear power, and many antinuclear movements began with regional characteristics and citizens were able to use this to their advantage. Canada has a split federalism system regulating nuclear power, while also balancing a split of public/private involvement in the nuclear power arena.
- Change in public perception on nuclear power after the Fukushima accident shaped the reactiveness of the government. Where the change in opposition to nuclear power was more pronounced, there was a movement from the government on the antagonism toward nuclear power. Russian public opposition did not massively increase following the accident, and the government was not motivated to respond in a lasting opposing policy to the concerns that may have been brought up by the accident. In Germany, there was an immediate and pronounced impact by the government from public disapproval of nuclear power. And in Canada, the public perception did not

really change following the accident and the government did not change its outlook on nuclear power.

- The role of technological research and development is key to explaining nuclear power. Russia and Canada each had their own infrastructure and hope for a nuclear powered future based on advances in nuclear power design (Russia, fast breeders and floating NPPs; Canada, advanced CANDU). Also, in both countries there was a strong sense of the prestige of scientific accomplishment that the nuclear industry brings to their country. While in Germany, attempts with fast breeders fizzled out and the industry lost momentum during the push for renewable energy.
- International collaboration on nuclear power and a push for exports of nuclear technologies abroad is a driving force for nuclear. In countries with a strong international draw to move into a global marketplace with their nuclear industry, they see the potential for economic benefits. In Russia, there is a widespread effort to extend the reach of the nuclear industry and promote a full range of nuclear products and services, from turnkey nuclear power plants to waste processing to nuclear management. Canada, likewise, is very interested in nuclear exports, although to a lesser extent than Russia as they have a lesser range of services able to be provided.
- The inclusion of an established and politically accepted green party can bring skepticism to nuclear. Most green parties are concerned with the environment and are likely to be unaccepting of the potential environmental threats posed by the generation of nuclear power, and having that standpoint represented in the political arena can be a powerful prospect for antinuclear policy change.

Russia has an extremely limited green party, which does not have representation in any large audience political body. Likewise, Canada also has a limited green party movement, and only one member to date has been elected to a national office. In contrast, Germany has a successful and well represented green party that has continually represented an antinuclear stance in a national political decision body.

These are some of the overall points of departure for the country case studies examined, but the four conditions which brought expectations about the kind of policy change outcome were particularly revealing.

6.4.1 *Advocacy*.

Strong advocacy in favor of nuclear power (Russia) saw a change towards being even more positively associated to nuclear power following the accident. Inversely, strong advocacy that was opposed to nuclear power (Germany) saw a policy change away from nuclear power. And in the case (Canada) where there was both a strong pronuclear and strong antinuclear coalition, the outcome was essentially the status quo.

6.4.2 *Nuclear Industrialization.*

The strength of the infrastructure and industry around nuclear prior to the accident revealed the prospects for an ongoing nuclear program. Russia and Canada both has extensive public (Russia) and private (Canada) nuclear corporations that can enable the nuclear industry to operate and brings with it a strong lobby effort in favor of nuclear power. Germany did not have such a strongly enabled nuclear industry, and lacked the supporting structure to advocate for nuclear power.

6.4.3 *Opportunity for Dissent.*

The degree to which the structuring of the system accomodates and accepts differences in opinion over nuclear power presents an opportunity for a minority opinion to seize and promote its agenda. Russia does not have high toleration for perspectives that are not in alignment with the government agenda and so there was not grounding for an established antinuclear movement to take hold. In Germany, a highly free multiparty system did have the opportunity for many different opinions to be voiced respective to policy choice, and enabling an outlet for perspectives that ran contrary to policy. Canada also had a high opportunity for dissenting opinions, but the effect is balanced in given its strong pro-nuclear lobby.

6.4.4 *Nuclear Narrative.*

How ta society views its experience with nuclear power helps to explain pro- and anti-nuclear sentiments. Russia had an embedded idea that nuclear power was technologically progressive and an economic engine for the country. While in Germany, nuclear power was treated skeptically from the beginning and much of the discourse about it is centralized around the negative effects that it brings. Canada, ever caught in the middle, is contested between two alternative narratives about nuclear and thus has a balance between opposition and favorability towards nuclear power.

6.4.5 *In Conclusion.*

So, what do all of these factors tell us about the possibility for policy change? There were attributes missing from the quantitative examination that we can gain from the qualitative investigation. The quantitative results of policy change were not able to give a clear sense of which indicators shaped policy decisions. There are implications to be gained from looking at the overarching structure of how nuclear power is approached within a country and what can be learned about policy change following a nuclear accident. This qualitative side of the dissertation has broke that element down across four dimensions advocacy, industrialization, opportunity for dissent, and the nuclear narrative. These conditions are hard to quantify, so they have been examined here qualitatively across three selected cases. Each of the four conditions plays into one another, but on the whole they are able to capture well the setting that displays the social, political, and economic factors shaping nuclear power policy.

There were certain expectations about the outcome of policy change after the Fukushima accident because of how those intervening variables would play into what the result of the policy window opening from the focusing event of the nuclear disaster. From Russia, there was a high level of pronuclear advocacy, a high degree of nuclear industrialization, a low level of opportunity for dissent, and a strong benevolent nuclear narrative, all of which led to pronuclear policy change. Germany displayed a high level of antinuclear advocacy, a low degree of nuclear industrialization, a high opportunity for dissent, and a strong deleterious nuclear narrative, bringing the conditions for antinuclear policy change under the right circumstances. Canada had a high level of pronuclear advocacy and a high level of antinuclear advocacy, a high degree of nuclear industrialization, a high level of opportunity for dissent, and a contested nuclear narrative that brings both the benevolence and antagonism toward nuclear power, which combined brings for a status quo assumption of nuclear policy.

While these are only three cases that have been examined, and present their own limitation in scope and other issues, they bring useful lenses for determining future pathways for policy change on nuclear energy. The approach here has been to track the associated conditions to draw out the implications of what kind of policy change emerges following an accident. Each case shown presents strong evidence from the country's history before and after Fukushima, of the country's experience with nuclear power, and how its narrative. In the following concluding chapter, an evaluation of the overall conclusions that can be drawn from using the quantitative and the qualitative chapters together.

Chapter 7

CONCLUSIONS

This dissertation has brought a more comprehensive and integrated perspective to the lasting impacts of nuclear accidents on policy change. In addition to introducing a new quantitative analysis method of the wide-scale factors at the country-level to understand nuclear policy, it provided a much-needed framework for explaining the different outcomes of antinuclear policy change, pronuclear policy change, and status quo continuance of policy in the aftermath of the 2011 Fukushima disaster. In this chapter, I review the findings from the previous chapters and provide some implications for theoretical development and policy practitioners. I then consider limitations of the research and propose future directions for researchers.

At the onset of this project, I set out to explain how and why states change their policies on nuclear energy after an accident. Puzzlingly, in some cases, a sharp antinuclear turn follows an accident, but in other cases an even stronger commitment to nuclear energy is retained in spite of the risks a major accident brings to the forefront. In a sense, the goal of this project was to identify the potential blueprint for the step-by-step process of policy change outcomes that a state may consider following an accident. To accomplish this, I used a lens of focusing event narrative from the agenda setting literature that shows how a nuclear accident might be seized upon to open a window for policy change. Furthermore, I demonstrate a structure through a combined quantitative and qualitative investigation to understand the key policy change outcomes through a case study examination.

7.1 Summary of Findings.

This dissertation utilized quantitative and qualitative methods to better understand policy change after the Fukushima nuclear accident. The results from each will now be summarized here in brief before turning to some of the theoretical and policy implications of the research:

- **Pronuclear Policy Change:** As the distance from the Fukushima site increases, the likelihood of adopting a pronuclear stance decreases. This result stands in contradiction to the common assumption that the farther a country is from an accident the more it is removed from the impacts. As another point, the quantitative results showed that higher the GDP growth rate, the greater the likelihood that a state would be pronuclear after the Fukushima accident. Additionally, in a stand-alone correlation, states that were less democratic had an increased likelihood of adopting pronuclear policy change. In the case of the Russian nuclear industry, the combination of a variety of factors contribute to a strong pronuclear advocacy. This environment as well as a strong nuclear industry, low public or political dissent, and a benevolent nuclear narrative created a context where following Fukushima a policy window opening for a pronuclear environment emerged.
- **Antinuclear Policy Change:** As human development level increases, there is an increased likelihood of antinuclear policy change. The population size variable was also significant, which implies that as population size increases the likelihood of a state adopting antinuclear policy stances increased. Democracy was an additional significant variable related to antinuclear policies. Rather unexpectedly, the results indicate that states that are

democratic are less likely to be antinuclear. This was contrary to the hypothesis that democratic states will be more likely to be antinuclear. Additionally, states with the more restrictive media freedom are less likely to be antinuclear. Germany has high levels of antinuclear advocacy, little existing nuclear industrialization and infrastructure, many opportunities for public and political dissent, and a prevailing nuclear narrative that was antinuclear. Combined, these factors all come together for antinuclear policy change following the Fukushima accident.

- **Status Quo Policy:** As the GDP of a country increases, there is a decreased likelihood of no policy change. Yet, as the level of human development increases, the likelihood of a country maintaining status quo on nuclear policies decreases. States that are more economically developed are more likely to pursue pro or antinuclear policies. As another point, the level of carbon dioxide emissions was significant, as the levels of CO_2 increased the likelihood of no policy change on nuclear energy also increased. Finally in the quantitative results, as the distance from Fukushima increased, the likelihood of a no policy change stance increased. This is more aligned with the original hypothesis. In the qualitative study, Canada had both high levels of antinuclear and pronuclear advocacy, high nuclear industrialization and infrastructure, a large opportunity for public and political dissent, and a nuclear narrative that was split between supporting and opposing nuclear power. This combination variables has brought together conditions that allowed for a continuance of nuclear policy that resulted in no substantive change on policy following the Fukushima accident.

7.2 Theoretical Implications.

This dissertation analyzed a rare and understudied event. There are not many instances of nuclear accidents to investigate, but even without many cases to study the results are still altogether interesting. What are some of the key insights from this project?

First, existing theoretical observations fail to adequately explain how nuclear accidents shape policies in other countries. What research does exist is not backed up by the quantitative evidence. As examined in chapter three, existing research identified many contending hypotheses to explain policy change on nuclear energy. Some of the hypotheses capture part of the evidence provided by the quantitative investigation, but others are not supported by the data from Fukushima. No one contending explanation reveals a complete account of the impacts that a nuclear disaster has on nuclear policy change. What this analysis does reveal is the impacts of nuclear accidents involve a series of complex interactions between the social, political, and economic landscapes of a state. In some cases, certain factors will matter more than in others because a slight adjustment in one aspect can significantly alter the policy environment.

Second, the public and policymakers perceive the risk of nuclear energy based upon a variety of different factors – which are often poorly understood. The four factors identified in the qualitative chapter can be used when factoring the risk perception toward nuclear energy. We can better understand how much of an assessment the "riskiness" of nuclear gets because of these four factors. The nuclear narrative factor demonstrates how the public and policy makers will be responsive to nuclear from a historical perspective. The advocacy coalition factor shows the ways in which coalitions can organize nuclear campaigns that reshape how individuals perceive the risk narrative. Opportunity for dissent shows how far forward these campaigns can actually go within the political system and advance particular alternative viewpoints. Finally, a state's existing nuclear infrastructure helps to explain affiliation to nuclear issues, for example as a beneficial security guarantor or as a harbinger of environmental destruction.

7.3 Policy Implications.

This dissertation provides an important contribution to the academic study of nuclear power policy; however, equally as important, it offers a number of implications for policymakers and practitioners. This dissertation has attempted to stay close to and accessible to policymakers, and its major takeaways are presented for consideration:

- **Nuclear accidents are an opportunity**. The aftermath of an accident can be seized for many different purposes and agendas. A nuclear accident opens a window that may then be framed by opportunistic groups with long formed agendas will seize to promote and drive their ambitions forward. Antinuclear groups may use the window to show the dangers of nuclear power. At the same time, pronuclear or industry groups may use the aftermath of an accident to enhance safety and environmental standards of nuclear energy in the aftermath of an accident.
- **The policy outcome is not always given.** Policy change after a nuclear accident is dependent on many factors. Policy makers should watch the factors as described in chapters 5 and 6 to figure out how they function in the system. For example, in a democratic system, there is more opportunity for negative

voices to be heard (likely with a highly provincial structure/local opposition opportunities). Certain factors can contextualize the post-accident policy choices.

- **History matters.** A nuclear accident does not happen within a vacuum. The accident occurs within a historical context that include a state's past experiences with nuclear energy. The context can either give weight to existing resentment or a strong industry that is ready to actively advocate to prove its advances.
- **Green party activism.** Following an accident, a green party or third party political movement may be able to gain seats and political legitimation. These parties may become more active than they were before the accident because they can frame the narrative based on their platform. In this new context, they may be more likely to give influence to minority opinions and provide antinuclear advocacy a larger platform and political legitimation or entrance into the arena.
- **Timing of elections.** The closeness of elections to the timing of a nuclear accident may matter. This impact depends on how those in power frame their reactions. In some cases it matters, but in others it does not. Elections can be used to bring in new leaders that are responsive to public concerns that are raised by and the immediate after effects of the accident. In this sense, the elections can be used to seize the agenda, however it is not a guarantee that elections alone will matter.

7.4 Limitations and Future directions for research.

With any project of this nature, it is important to acknowledge potential limitations of the findings and implications identified above. To conclude, I would like to address potential avenues for future research. In regards to the cases presented here, there remain several unanswered questions that could be assessed in more detail in future projects.

The number of existing cases available proved to be a limited factor. This is the case for several reasons, but the weaknesses of the small sample size and justification of the approach taken here has already been extensively addressed in chapter four. Both of these factors inherently limit the number of cases and observations that can be reasonably included in one project. However, future endeavors could increase the number of observations by conducting more process tracing across more cases to increase the statistical significance of the findings. The three case studies were relatively limited in scope, and further case study analysis should focus on more depth in the cases selected and in more width in number of other alternative country cases that would have proven of interest to study, could add a new richness in with elaborated analysis. Additionally, future iterations the quantitative chapter could expand the temporal basis to include states on a yearly basis, which would bring the sample size up to a large N range and overcome some of the modeling difficulties of this study.

While that approach may mitigate the concerns about small sample size, there is a further issue that it may not be possible to overcome: nuclear accidents fall into rare event traps. Nuclear accidents on the magnitude of Fukushima are rare, so it is possible to over-extrapolate the results of this study. To combat this, future research could be directed to compare the results of the nuclear accidents we do have, by looking at Three Mile Island, Chernobyl, and Fukushima and analyzing the quantitative indicators of policy change to better understand the dynamics at play. Additionally, by comparing the case examples we do have of nuclear accidents, we can see how policy change waves may change over a long duration of time.

An additional limitation of this project is a problem that plagues the nuclear energy field: favorable economics to nuclear energy. While a common critique of the loss of nuclear momentum following an accident relates to changes in the regulatory or risk frameworks, unfavorable economics are the biggest detractor from the future potential for nuclear energy. This project is unable to undertake a full scale economic analysis of nuclear market forces, which is a considerable drawback given that new nuclear projects are largely subjective to market forces. Nuclear energy necessitates significant investment, effort, and time from the governments and utilities involved, from sophisticated technology, to licensing, to construction, to environmental impact assessments. Therefore, the price must be right or advancement will not proceed forward. At the dawn of the twenty first century, the market looked favorable to nuclear energy as other energy sources remained relatively expensive. However, as seen in the United States with the shale gas revolution, when other sources of energy become more competitively advantageous, the desire for upfront expensive nuclear can be tamed by the market. Future research should study how policy changes after a nuclear accident with an economic analysis as it can uncover whither the focusing event of an accident goes: is agenda seized by opportunism, structure, and historical context, or does the market promote conclusions about the direction of nuclear energy futures?

While there are lingering questions, this dissertation has brought forth several new lenses from which to view nuclear accidents and their impact in shaping the future of a state. From this research, we have a better understanding of policy change, agenda setting mechanisms, and focusing events following disasters. Although no one hopes that a new nuclear disaster will happen in the future, this dissertation provides insight for policy makers and scholars should they face the aftermath of such an extreme event. Moreover, should such an event never transpire again, the provisions brought up under this research illuminate implications for other disaster types or forces that bring about policy change.

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