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The Energy Frontier: Exploring the Future of Commercial Nuclear Power in Canada, Finland, and Germany

by

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Abstract

A state has a plethora of options when it comes to electricity generation. In the case of nuclear power, it is not a simple yes/no or present/absent dichotomy as it is often portrayed in the literature. A state that has existing nuclear capacity can choose to: expand, maintain, or phase out nuclear power. It will implement one of these three policies towards nuclear power for a variety of political, social, and economic reasons; the challenge is to discern the criteria used in reaching these policy outcomes. Using Finland, Canada, and Germany, this project explores most similar cases with differing outcomes during the nuclear renaissance (2000-2015). Each case is illustrative of one of the three possible trajectories for a state already in possession of at least one commercial nuclear power plant. This dissertation sought to better understand why they choose such divergent policies around nuclear power during this period of study.

Its findings confirm the literature's claim that nuclear expansions are most likely to take place within governance models that are centralized, technocratic, and involve limited public engagement. As electricity planning shifts away from centrally planned, technically-informed decisions among experts to a more democratic process, with an increased emphasis on social considerations, large-infrastructure projects like nuclear power plants will become that much more challenging to advance. Taken together with the rising costs of building new reactors, it will greatly limit where new construction will seriously be considered.

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Dedication

This dissertation is dedicated to my late grandfather, D.C. Torre. Thank you for your endless love, support, and encouragement. You were an inspiration to me throughout my graduate studies.

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List of Abbreviations

ABWR	Advanced Boiling Water Reactor
AEA	Atomic Energy Act
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
AEK	Finnish Atomic Energy Commission
APM	Adaptive Phased-Management
APR 1400	Advanced Power Reactor 1400
ASN	Autorité de sûreté nucléaire
BBU	Federal Association of Citizen Initiatives for Environmental Protection
BfS	Federal Office for Radiation Protection
BGE	Federal Company for Radioactive Waste Disposal
BMFT	Ministry of Research and Technology
BMUB	Ministry for the Environment and Reactor Safety
BRIC	Brazil, Russia, India, and China
BUND	Federal Council for Environmental Protection
BWR	Boiling Water Reactor
CANDU	Canada Deuterium Uranium Reactor
CCGT	Combined Cycle Gas Turbine
CCNR	Canadian Coalition for Nuclear Responsibility
CDM	Clean Development Mechanism
CDU	Christian Democratic Union Party
CEA	Commissariat à l'énergie atomique

CEAA	Canadian Environmental Assessment Act
CEO	Chief Executive Officer
CLC	Community Liaison Committee
CNA	Canadian Nuclear Association
CNL	Canadian Nuclear Laboratories
CNS	Canadian Nuclear Society
CNSC	Canadian Nuclear Safety Commission
CSR	Corporate Social Responsibility
CSU	Christian Social Union in Bavaria
DGR	Deep Geological Repository
DiP	Decision-in-Principle
E.ON	Energy On
EA	Environmental Assessment
EC6	Enhanced CANDU 6
EDF	Électricité de France
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EnBW	Energie Baden-Württemberg AG
EPR	Evolutionary/European Pressurized Reactor
ESK	Commission on Radiological Protection
ETS	Emission Trading System
EU	European Union
FDP	Free Democratic Party

FOAK	First-of-a-kind
GHG	Greenhouse Gas
GW	Gigawatt
GWe	Gigawatt Electric
HEPCO	Hydro-Electric Power Commission of Ontario
HLW	High-level Waste
HLWC	Commission on the Storage of High-Level Radioactive Waste
I&C	Instrumentation and Control System
IAEA	International Atomic Energy Agency
IESO	Independent Electricity System Operator
IPCC	Intergovernmental Panel on Climate Change
IPSP	Integrated Power System Plan
IVO	Imatran Voima
JRP	Joint Review Panel
KEPCO	Korea Electric Power Corporation
KFK	Commission on the Review of Funding for the Phase-Out of Nuclear Energy
kW	Kilowatt
kWh	kilowatt-hour
KWU	Kraftwerk Union
LTEP	Long-Term Energy Plan
MEE	Ministry of the Employment and the Economy
MOE	Ministry of Energy

MOU	Memorandum of Understanding
MOX	Mixed Oxide Fuel
MP	Member of Parliament
MTI	Ministry of Trade and Industry
MW	Megawatt
MWe	Megawatt Electric
NDC	Nationally Determined Contribution
NEA	Nuclear Energy Agency
NEB	National Energy Board
NIMBY	Not-In-My-Backyard
NNWS	Non-Nuclear Weapons States
NDP	New Democratic Party
NPD	Nuclear Demonstration Plant
NPP	Nuclear Power Plant
NPT	1968 Non-Proliferation Treaty
NRC	US Nuclear Regulatory Commission
NRCan	Natural Resources Canada
NRX	National Research Experimental
NWFA	Nuclear Fuel Waste Act
NWMO	Nuclear Waste Management Organization
NWS	Nuclear Weapons States
O&M	Operation and Maintenance Costs
OCNI	Organization of Canadian Nuclear Industries

OEB	Ontario Energy Board
OECD	Organization for Economic Co-operation and Development
OEFC	Ontario Electricity Financial Corporation
OL3	Olkiluoto 3
OL4	Olkiluoto 4
OMERS	Ontario Municipal Employees Retirement System
OPA	Ontario Power Authority
OPEC	Organization of the Petroleum Exporting Countries
OPG	Ontario Power Generation Inc.
PBNC	Pacific Basin Nuclear Conference
PEST	Political, Economic, Social and Technological Factors
PPA	Power Purchase Agreement
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PVO	Pohjolan Voima
PWR	Pressurized Water Reactor
R&D	Research and Development
RFP	Request for Proposals
RPV	Reactor Pressure Vessel
RSK	Reactor Safety Commission
RWE	Rheinisch-Westfälische Elektrizitätswerke
S&T	Science and Technology
SLO	Social Licence to Operate

SON	Saugeen Ojibway Nation
SPD	Social Democratic Party
STUK	Radiation and Nuclear Safety Authority
TSO	Transmission System Operator
TVO	Teollisuuden Voima Oy
UAE	United Arab Emirates
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
VTT	Technical Research Centre of Finland
WWF	World Wildlife Federation

Chapter 1: Introduction

Nuclear power has for decades held the promise of providing a virtually limitless source of cost-effective and low-emissions electricity, to be used for the purposes of human development and flourishing. In practice, the technology has been marred by accidents, costly development, underperformance, and the specter of misuse and weaponization. Its first major expansion during the 1960s and early 1970s was spurred by technological optimism and the pursuit of a low-cost alternative to coal and oil. This led to its commercial development in over 30 countries. The technological optimism and lofty targets initially promoted by industry that had made nuclear technology attractive in the first place quickly faded as construction experience accrued, and an inordinate number of delays and cost overruns became associated with the technology. This era of expansion had all but collapsed by 1979 when the first major nuclear accident at Three Mile Island shook public confidence in the technology as a panacea for our energy future.[1]

In an increasingly carbon constrained world, there has been a renewed interest in revisiting the large-scale use of commercial nuclear power as a means of achieving energy security from a proven low-carbon energy source (Deutch et al. 2003; Findlay 2012). At the turn of the century, there was hope that the nuclear industry could turn a corner, overcome past barriers to the development and expansion of the technology leading to a global revival. The so-called "nuclear renaissance" promised a massive

[1] Orders for nuclear reactors had slowed considerably by 1974. Walker and Lönnroth (1983) note that orders had dropped from an average 33GW of new nuclear capacity per year in the West during in the early 1970s to an average of 12GW by the latter half of the decade. In the United States, none of the 99 operating reactors were ordered after 1974 (Davis 2011). Only 50 of the 197 reactors on order as of 1974 were ever completed (ibid.).

global expansion, with the potential of doubling global nuclear capacity by 2050. Its proponents have portrayed nuclear power as a mature technology that has the potential to meet the large baseload generation needs of a modern society with almost zero carbon emissions (Pacala and Socolow 2004; Kharecha and Hansen 2013). For its critics, nuclear power presents a Faustian bargain; its emissions-free electricity saddles society with nuclear waste for hundreds of thousands of years, with the added threat of nuclear accidents, like those experienced at Fukushima and Chernobyl (Sovacool et al. 2013; Ramana 2011; Ethics Commission for a Safe Energy Supply 2011; Winfield et al. 2006; Sierra Club Canada 2011). They insist that nuclear power is not worth the risk posed by the threat of accidents or the mishandling of nuclear waste, and add that it is costlier than existing renewable alternatives.

A state has a plethora of options when it comes to electricity generation. In the case of nuclear power, it is not a simple yes/no or present/absent dichotomy as it is often portrayed in the literature. A state can choose to adopt, expand, maintain, reboot, defer, reject, phase out, or remain agnostic towards nuclear power. A state will implement one of these eight policies towards nuclear power for a variety of political, social, and economic reasons; the challenge is to discern the criteria used in reaching each of these policy outcomes.

This project seeks to identify some of the key factors that serve to shape the policy outcomes within democratic states that currently possess commercial nuclear reactors. To that effect, this dissertation asks: what factors have shaped a state's decision to expand, maintain, or phase out capacity during the nuclear renaissance (2000-2015)? Using Finland, Canada, and Germany, this project explores most similar cases with

differing outcomes. Each case is illustrative of one of the three possible trajectories for a state already in possession of at least one commercial nuclear power plant (NPP). This dissertation seeks to better understand why they chose such divergent policies around nuclear power during this period of study.

Building, refurbishing, or decommissioning a nuclear plant is not as simple as a purchase order, memorandum of understanding (MOU), or a parliamentary approval. There is no guarantee a project will ever get off the ground let alone be completed based solely on one of these documents or decisions. In the case of a phase out, those political decisions are implemented over a long period of time and have been subject to political reappraisals, deferment, and uncertainty (e.g. Sweden, Italy, and Germany). Given the long-term nature of these energy policies, there are multiple stages in their development and implementation that are vulnerable to disruption, revision or reversal. For example, a government may have ambitious plans to expand their nuclear energy capacity and end up simply maintaining their existing capacity as a result of domestic irritants, exogenous shocks, or some combination thereof. Put another way, a state's current nuclear trajectory can have a clear intent and objective, but may be altered in important ways as it is implemented over time. Any nuclear decision will be revisited and challenged at multiple junctures along the way as it gradually moves towards implementation. Its success will depend on a long-term commitment from a variety of stakeholders involved in the decision-making process.

This chapter will outline the broad contours of the problem, and how this phenomenon can be better explained through a new approach to the study of energy policy and civilian nuclear power programs.

The Promise of a Nuclear Renaissance: A Primer

During the 1990s, nuclear power plants were characterized as "stranded assets" or sunk costs, that tended to lose money for their operators (Nuttall and Taylor 2008: 7). In the United States (US), their poor performance had made them increasingly unprofitable and led to plant closures well ahead of their planned operating lives. Ultimately this led to the sale of many reactors in an effort on the part of utility companies to divest themselves of their nuclear assets, leading to a consolidation within the US market of nuclear operators. Consolidated nuclear operators were able to improve the performance and reliability of their NPPs through a steady stream of investments into their operation and maintenance. They were able to improve the value of these plants and alter the general outlook surrounding investment in the technology. Improved performance led operators to seek 20-year licence renewals to extend the life of these increasingly valuable and amortized assets. More importantly, it led utility companies to consider ordering new units for the first time in over two decades. Rising fossil fuel prices, in conjunction with the improved performance of American reactors, fed into a widespread optimism at the turn of the century that saw the possibility of a global nuclear resurgence. The promise of a new era of nuclear reactor construction on a scale not seen since the 1970s was portrayed as being imminent (Deutch et al. 2003; Nuttall and Taylor 2008).

The technological optimism behind proponents of the so-called "nuclear renaissance" portrayed nuclear power as an attractive low-carbon option that was becoming increasingly viable when pitted against rising fossil fuel prices. It was further bolstered by promises from industry that new designs would shorten construction schedules and improve safety, while making nuclear power cost competitive with

comparable baseload technologies (Joskow and Parsons 2012). Nuclear power was being promoted by industry as a clean, safe, and affordable alternative that could be used to meet an ever-growing global demand for electricity in a sustainable fashion.

A 2003 MIT Study titled, *The Future of Nuclear Power*, asserted that for nuclear power to be competitive with coal and gas, the industry would need to reduce construction costs associated with NPPs by 25 percent from existing estimates and cut construction times on a per plant basis from five to four years. They would also need to find commercial financing for new construction at a rate that was comparable with what was available for alternative technologies, while finding new efficiencies to lower general operation and maintenance (O&M) costs. Securing generous financing terms, loan guarantees, and/or fixed prices on next generation reactors would be the only way for them to be competitive with other baseload technologies while technical and construction problems were being sorted out for these first-of-a-kind (FOAK) designs. Few if any reactors had been built in most countries for over two decades. The demands on an industry that had an aging work force, a crippled supply chain, and limited recent experience in the construction of NPPs would be substantial. There would likely be a period of readjustment for the industry as it worked to regain lost skills, reestablish supply chains, and recover the knowledge needed to build a new reactor. The report concluded that a large-scale nuclear resurgence would be difficult to achieve without a substantial price being levied on carbon emissions accompanied by a large decrease in the price for a new reactor (Deutch et al. 2003).

More than 10 years after the MIT Study was first published (Deutch et al. 2003), reactor construction costs have tripled (Bradford 2013), and the first units to begin the

refurbishment process have experienced substantial delays and cost overruns (Cadham 2009; Bratt 2012).[2] As a result, most countries have failed to build a new reactor, let alone a fleet of modern plants. Perhaps not surprisingly, there has also been a failure to establish a stable price on carbon emissions in most markets (Bradford 2013). Even in Europe, the Emissions Trading System (ETS), the world's first international system designed to put a price on carbon has failed to establish a consistently high price on these kinds of emissions (Murray 2014; Twidale 2017).[3]

It is quickly becoming apparent that only a minor global nuclear expansion is likely to take place. This limited revival has principally been taking place within states with existing nuclear power programs. Only a handful of newcomers have broken ground on new reactors since the year 2000 and they are principally located in the developing world (Findlay 2012; IAEA 2017a).

Commercial nuclear power continues to be plagued by many of the same problems that hampered the first global expansion: cost, safety, and social acceptance. Construction costs have only gone up following accidents like Three Mile Island, Chernobyl, and Fukushima. Concerns over safety have increased regulatory scrutiny in most jurisdictions to the point that nuclear power is no longer seen as economically feasible and/or socially acceptable.

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[2] John Cadham (2009: 7) notes the first effort to refurbish a unit in Canada at the Pickering Plant was three years behind schedule and cost triple the originally forecasted price. The second unit refurbished at Pickering did restart on schedule but was approximately 50 percent over budget.

[3] In March 2014, the ETS emission allowance price dropped to a record low €3.71/tonne. While the price has since rebounded, it remains below what had been thought to be a stable price at €7/tonne. For a more detailed discussion on ETS allowance price issues see (Murray 2014; Twidale 2017).

While in years past, interest in the technology had been driven by the pursuit of nuclear weapons (Sovacool and Valentine 2012; Jewell 2011a), the desire to acquire nuclear power in the twenty-first century is no longer seen as shorthand for interest in the bomb. Continued interest in commercial nuclear power is principally driven by energy and environmental security concerns.

Current International Trends for Nuclear Power

Nuclear power has been heralded as a means of power generation for decades, but from a commercial vantage point it has failed to gain a foothold in most markets. Nuclear accidents at Three Mile Island and Chernobyl led to a number of cancellations for reactors and the rollback of a number of commercial programs around the world. Sales of nuclear reactors all but dried up in most Western democratic countries over the next two decades.

Talk of a potential global nuclear renaissance has gone on for over a decade as a result of increased fossil fuel prices and a growing concern over carbon emissions. As late as 2009, there were 50 states seriously assessing the possibility of building their first nuclear reactor, with a number of developed states exploring options for how to extend the life of their existing reactors and considering the potential for new plants (Miller and Sagan 2009).[4]

Today, optimism surrounding a global nuclear revival has begun to wane, particularly in the developed world following the 2011 accident at the Fukushima Daiichi Plant (Davis 2011). That being said, much of the so-called nuclear renaissance remains

[4] Findlay (2012) suggests that this optimism may have been ill warranted. The 50 states that the IAEA was referring to included countries that had done any level of consultation with the IAEA, and not necessarily those with a serious interest in nuclear power.

on track for the developing world. The 2012 *International Atomic Energy Agency (IAEA) Report on the Prospects for Nuclear Power* suggests that the accident at Fukushima may have dampened but not reversed the renaissance. As of 2017, the IAEA reports 28 countries still actively "considering, planning or starting [new] nuclear power programmes" (IAEA 2017b). Optimism for a nuclear renaissance has been further dampened by major engineering firms like Toshiba-Westinghouse and Areva's inability to deliver their flagship next generation (Generation III+) reactors on time or on budget (Stapczynski 2017; Hibbs 2017). These two experienced vendors were expected to dominate this new era of nuclear expansion, however, following the 2016 decision to restructure Areva's failing reactor division and the March 2017 announcement that Westinghouse was entering bankruptcy protection, the future seems far less certain (WNN 2016B; Maloney 2017a; Inagaki et al. 2017).[5]

Today, there are 57 reactors under construction in 16 different countries,[6] 19 of which are being built in China alone (IAEA 2017a). Of those 16 countries only Belarus and the United Arab Emirates (UAE) are nuclear newcomers. Of the 57 reactors under construction, 40 of them are being built in six states: Taiwan (2), China (19), India (6), Pakistan (2), the UAE (4), and Russia (7), suggesting that the vast majority of the nuclear renaissance will take place in the developing world. There are still a handful of reactors

[5] The Westinghouse Electric Company is a subsidiary of Toshiba. The Japanese conglomerate purchased the US-based firm in 2006. Areva is French state-owned corporation responsible for building the country's nuclear fleet. Électricité de France S.A. (EDF), France's state-owned utility, will take a majority ownership stake in the newly formed New NP following the restructuring (WNN 2016B; De Clercq 2017). Until recently, both were considered global leaders in the nuclear reactor business with new builds planned in countries all over the world.

[6] This includes Taiwan, which the IAEA does not list as a country.

being built in the developed world, but those that remain interested in nuclear power are more likely to seek extensions on their operating licences and refurbish existing capacity. For example, in Canada, recent efforts to build new units at the Darlington and Bruce sites have been shelved in favour of refurbishing existing capacity (WNA 2017f).

Given these trends, while new construction may be principally taking place in the developing world, most of the 448 reactors in the global fleet will continue to operate in the developed world for the foreseeable future (IAEA 2017a; IAEA 2017b).[7] In the US, of the 99 reactors in operation, 87 have received 20-year license extensions, with the remaining reactors likely to be approved in the near term. By contrast, only two new reactors are likely to be completed by 2023 in the US (WNA 2017b; Bade 2017).[8]

Other states have either begun the costly process of a nuclear phase out or have committed themselves to do so by a date in the near term (e.g. Germany, Belgium, Switzerland, and Spain). The current installed global capacity of nuclear power is expected to decrease by 2030, from 392 GWe to 345 GWe according to IAEA projections (IAEA 2017b).[9] As of 2015, nuclear power provides less than 11% of the

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[7] Commercial nuclear power reactors operate in 31 different countries (if we include Taiwan) as of September 2017 (IAEA 2017a).

[8] The two reactors under construction in Georgia remain in doubt following the March 29, 2017 announcement by Toshiba-Westinghouse that they were filing for bankruptcy and the recent cancellation of the V.C. Summer expansion in South Carolina (Bade 2017; Caldwell and Soble 2017). Toshiba-Westinghouse is the engineering firm responsible for the construction of the two new reactors at Vogtle in Georgia. There are ongoing negotiations with Toshiba in order to find a way to complete them. For a detailed discussion on the challenges facing Toshiba-Westinghouse and the new build projects in the US, see: (Bade 2017; Inagaki et al. 2017; Maloney 2017b; Schneider and Froggatt 2017).

[9] These figures reflect the IAEA's (2017b) low projection for nuclear growth. It assumes "that current trends will continue with few changes in policies affecting nuclear power." Nuclear power is expected to recover, and return to current levels by 2050. On the high end, the IAEA projects 554 GWe of installed global capacity by 2030. Given current

world's electricity generating capacity, its lowest share since 1982 (ibid.).[10] The average age of the global nuclear fleet is 29.3 years, with reactors typically being licensed to operate for 40 years without refurbishment (Schneider and Froggatt 2017).[11] Of the 51 reactors completed since 2007, the average construction time has been 10.1 years, far longer than had been hoped for by the industry (ibid.). If the current pace of construction is any indicator of the world's nuclear future, capacity will retire much faster than it can be built in most countries unless there is a substantial increase in the number of reactors ordered and a considerable improvement in the speed of their delivery.

There are a number of obstacles that prevent a country from building, refurbishing, and continuing to operate a fleet of reactors. The complexity of energy policy decisions in conjunction with the limited expansion of the technology in recent years have made it difficult to identify the key variables that explain specific policy trajectories in the area of nuclear power. The small number of states that have succeeded in building new NPPs or refurbishing existing capacity defy any straightforward classification. Part of the problem with solving this puzzle has been the somewhat painful

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construction times, supply chain constraints, and the cost of nuclear power, I see the high projection as exceedingly unlikely.

[10] Schneider and Froggatt (2017) note that nuclear power constituted 10.5 percent of the world's electricity generation capacity in 2016. This is down from a high of 17.5 percent in 1996 (ibid.).

[11] 40 years is the standard length of an operating licence in the US. As noted earlier, most of the American fleet has received 20-year life extensions, allowing them to operate for a total of 60 years. Schneider and Froggatt (2014) assert that this does not mean that they will necessarily operate for the period that they are licensed for, noting that none of 32 reactors removed from service in the US operated for 40 years. Doubts over the future of the American nuclear fleet have been heightened by the closure (or announced closure) of 14 reactors since October 2012 (Larson 2016). By 2025 it is expected that the US will only have 61 reactors in operation as nuclear power struggles to compete with natural gas and subsidized renewable sources of electricity in liberalized markets (Gold and Sweet 2017).

realization that their energy choices tend to be based on a whole host of factors that do not lend themselves to a systematic, check-the-boxes account. While there are variables that might make a country likely to adopt, maintain or expand the use of nuclear power, countries often diverge from these expected outcomes (Gourley and Stulberg 2013). Similarly, those that phase-out the technology or choose to delay/defer the development of a policy on nuclear power do not necessarily fit a specific mold.

Considerations for Nuclear Power in the Twenty-First Century and Beyond

There are several factors that differentiate the nuclear renaissance from past periods of nuclear expansion. These differences are highlighted by: (1) the increasingly commercial orientation of nuclear programs that have little relation to weapons development;[12] (2) electricity markets that are becoming increasingly liberalized, meaning that new generating stations must be competitive with alternatives in order to be selected and built; (3) the lack of recent experience with reactor construction means that there is a considerable learning curve for both aspirant and existing nuclear states interested in building new capacity;[13] (4) the new safety concerns arising from a series of accidents in the industry have led to the adoption of increasingly complex Generation III/III+ reactor designs, which have in turn affected regulatory requirements, and further increased construction costs and build times; [14] (5) the more significant role for the public

[12] One example of this shift is the limited number of states that have domestic commercial scale enrichment or reprocessing facilities.
[13] In the past, the difference would have been more pronounced. Today very few countries have a robust nuclear supply chain able to initiate new reactor construction with ease. The *World Nuclear Industry Status Report 2016* notes that all countries currently building new capacity are experiencing delays including China. In the case of China, half of the reactors under construction are behind schedule (Schneider and Froggatt 2016).
[14] As noted earlier, cost projections have more than tripled from 2003 to 2013 rather than decreasing by the expected 20 to 25 percent required to make them competitive with

and the perceived need for social acceptance; and, (6) the growing pressure on utilities to implement a long-term waste management plan (in the near term) as a prerequisite for the continued development of nuclear power.

To nuclear critics' dismay, all of these challenges and delays have not stopped the development of nuclear power. Reactors continue to be refurbished, new units continue to be built, with only a small handful of states actively phasing out the technology. What continues to make nuclear power attractive to states that build and operate NPPs in the face of these growing obstacles?

Energy Security and the Environment

In recent years, the nuclear industry has actively promoted Generations III/III+ reactor designs as safe, low-carbon, cost-competitive, and capable of producing large amounts of electricity from a widely available fuel source (Szarka 2013; Rogers-Hayden and Lorenzoni 2011). This narrative presents nuclear power as a technological solution to address issues of energy security and the environment. As we will see in the next chapter, these claims are somewhat exaggerated and yet the promise of a clean, abundant, and reliable source of electricity is attractive to a growing number of countries seeking to meet a growing demand in a carbon conscious and cost competitive fashion.

Energy security traditionally refers to a "a condition in which a nation perceives a high probability that it will have adequate energy supplies…at affordable prices" (Deese

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other conventional alternatives (Deutch et al. 2009; Bradford 2013; WNA, 2017d). While it had been hoped that reactors in this new era of expansion would be built in 4 to 5 years (Deutch et al. 2003) this has not proven to be the industry norm, often taking twice that amount of time. By contrast, a typical coal plant can be built in 4 years and a gas plant in 2 years (Davis 2011).

1979/1980: 140).[15] Today the concept has been expanded to include questions of acceptability in addition to affordability and availability (Cherp and Jewell 2014; Hughes 2012).[16] For our purposes, acceptability refers to both social acceptability as well environmental acceptability.[17]

The environmental dimension is unique to this period and may play a significant role in promoting nuclear development. While industry has been keen to advertise this feature, it is unclear whether governments and their respective citizens are convinced of this benefit.[18] Traditional elements of energy security (affordability and availability of supply) taken together with concern for the environment, are believed to be the principal drivers behind nuclear expansion in the twenty-first century.

Chapter-by-Chapter Overview

In the following chapters, this study will identify in greater detail the deciding factors that have led wealthy democratic states with an established fleet of commercial

[15] Nuclear power has traditionally been relied on heavily by countries like Japan and France in order to diversify their energy supply mix and provide a low-cost alternative to fossil fuel imports. Nuclear power was seen as an important means of maintaining energy security given the limited availability of domestic sources of energy. Japan imports roughly 85 percent of its primary energy needs, while France imports nearly 50 percent (WNA 2014). They are examples of countries that made nuclear power a central component of their respective national energy policies in response to the 1973 energy crisis (WNA 2014; Yergin 1988). Both are in the process of revisiting support for their respective nuclear power programs following the Fukushima accident (Schneider and Froggatt 2017).

[16] Energy security is a highly contested concept with many competing definitions. For a critical review of the energy security literature see: (Cherp and Jewell 2014; Sovacool and Brown 2010; Ciută 2010).

[17] For Hughes (2012: 222) acceptability refers only to "respecting [environmental] concerns."

[18] Critics of nuclear power are quick to point out that these industry promises are simply the newest tactic being used to manipulate public opinion in order to justify the high cost of nuclear power (Wynne 2011).

nuclear reactors to maintain, expand, or phase out nuclear power during the current era of nuclear expansion. Its overall objective is to provide a better explanation of what shapes a state's decision to continue to develop nuclear power (either through refurbishment, new construction, or both), and by contrast, what leads similarly situated states to decide to reject the continued operation of its reactors and actively plan for their shut down and eventual decommissioning.

Chapter 2 begins by outlining some of the existing literature's explanations for nuclear energy policy and their approach to understanding the growth, stagnation and rejection of commercial nuclear power in many markets. While various disciplines (including political science, economics, psychology, engineering, and sociology) provide partial explanations of the factors that shape what drives a state's overall policy on the continued use of commercial nuclear power, this research project makes the case that a synthesis is needed to provide a more complete causal account.

Chapter 3 will elaborate on this synthesis and present a series of hypotheses to be tested in order to develop an analytical approach that helps to better explain nuclear policy within democratic states, with a focus on states that currently possess the technology (Canada, Germany, and Finland). It will outline the case selection criteria used by this study, followed by a discussion of the methodology employed by this dissertation. This study employs an inductive method used to identify the broad factors explored and tested within each case. They serve as points of entry, with the aim of identifying the more salient features of the decision-making process. Ultimately, this will allow the researcher to draw out stronger conclusions from a richer frame of reference to gain a better understanding of the dynamics that inform nuclear energy policy today.

Chapter 4 will test these hypotheses against the case of Finland, the first of three case studies explored in this dissertation. Finland is in the process of completing the first new reactor ordered in Western Europe since 1986, with another expected to begin construction in 2018. The Olkiluoto 3 NPP was ordered in December 2003 and has been plagued from the outset by delays and cost overruns (Thomas and Hall 2009; Joscow and Parsons 2012). Originally slated to be completed in 2009, it is now expected to enter service no earlier than 2018. Finland is also expected to begin construction of another NPP on the Hanhikivi peninsula in the municipality of Pyhäjoki in late 2018 (WNA 2017g). Finland provides an interesting case of a northern democratic state, with a liberalized electricity market, and over 30 years of experience of using nuclear power with unambiguous plans for the expansion of its nuclear fleet.

Chapter 5 explores Canada, the second case in this dissertation. The Canadian chapter will focus on the province of Ontario and its choices regarding nuclear power. While as recently as 2009 there were bids sought for two new units at Darlington, the focus has shifted to refurbishment of existing capacity (WNA 2017f). The province's multi-billion-dollar refurbishment plan is designed to maintain its capacity through to the 2060s. The province is clearly committed to the technology for the long term and yet it has no plans to build new reactors for the foreseeable future. This chapter will explore what factors have led to this outcome.

Chapter 6 will look at Germany, a country that has long toyed with the idea of a nuclear phase out. Early calls for a nuclear exit began in the 1970s but failed to gain traction until the late 1990s. Following the 2011 Fukushima Daiichi accident in Japan,

those plans were expedited.[19] For a country that produced roughly 25 percent of its electricity via nuclear power prior to March 2011, this was a serious readjustment for their electricity generation portfolio (WNA 2017e). This chapter will explore the political context in which this policy developed and how it gradually served to transform the future of the German electricity supply mix.

Chapter 7 will provide an overview of the findings from the three case studies included in this dissertation and explore the areas of convergence and divergence in policy development. In short, it seeks to identify the lessons learned from these three different policy trajectories and the implications that they might have for other states who operate NPPs. It identifies the overarching conditions that serve to create windows of opportunity for nuclear expansion and the points of veto and vulnerability that can serve to alter or reverse them. It will conclude by providing an overview of the emerging analytical framework created by this dissertation, and the implications it has for the future study of policy pertaining to commercial nuclear power development and energy policy broadly speaking.

[19] The original political decision to commit to a nuclear phase out was made in 2000. The goal was to shut down all existing NPPs by ~2022, however there had been a decision in 2010 to extend the operating licences of these plants beyond the 2022 deadline. Following the Fukushima accident eight reactors were shut down temporarily while Germany reviewed the safety of its plants. This decision was made permanent in June 2011 with the remaining nine reactors set to go offline by December 2022.

Chapter 2: Literature Review

This chapter will begin by exploring how the existing literature has tackled the question of commercial nuclear power and explore some of the limitations of these approaches. This chapter will explore some of the contributions made by the security studies, economics, and risk literature. Taken together, they comprise what might be referred to as the nuclear power literature.[20] Each of these bodies of literature looks at the development of nuclear power from a slightly different vantage point, that when isolated provide only a partial explanation of what is going on. This chapter sets out to flag key contributions from these literatures that will be used to inform the development of a new approach that better reflects the determinants of commercial nuclear power programs in the twenty-first century amongst democratic states with a long history of operating NPPs.

The focus of much of the literature to date highlights the future of nuclear power in the US rather than a balanced approach that considers alternative models of development abroad (see for example, Deutch et al. 2003; Daedalus 2009 Special Issue: "The Global Nuclear Future"; Findlay 2012). There are passing mentions of BRIC (Brazil, Russia, India, and China) countries and nuclear newcomers, but they tend to be grouped together. More problematic has been the assumption that future nuclear growth will resemble earlier eras of expansion.

When looking at the US and other historical cases, they can provide some insights into the development of a nuclear program, but we need to be cognizant of how

[20] This literature focuses on the issues facing nuclear power development and does not necessarily draw on a broader theoretical framework. For example, security studies literature on nuclear power (Findlay 2012; Stulberg and Furhmann 2013; Furhmann 2012) is for the most part not drawing on theoretical approaches to international relations, comparative politics, or public policy in a substantive way.

circumstances have changed, and what factors remain relevant and what factors have become less salient over time. Even if we were to focus on the American market, we would quickly see how energy policies have evolved. What motivates contemporary American utility companies to extend operating licences for their existing nuclear fleet is distinct from the motivations that led them to build reactors during the 1950s and 1960s.

Ferenc Toth (2008) notes that many of the existing studies on the nuclear renaissance are quantitative in nature and global in scale, and as a result, miss a great deal. "This global top-down approach has many virtues…however, the rich details of regional features, the historical and current social, economic and political intricacies of nuclear power and how they shape its future in geopolitical areas often remain hidden or are ignored altogether" (Toth 2008: 7). The political, economic, and social context of a country helps to shape its domestic discourse and its overall perception of nuclear power. For example, South Korea's anti-nuclear movement had until recently been largely muted as a result of widespread knowledge of the country's energy needs and the lack of domestically sourced alternatives. Instead of opposing nuclear power, public interest groups have traditionally pushed for increased safety and regulation of the industry (Sung and Hong 1999).[21]

Bernard Gourley and Adam Stulberg (2013: 42) suggest that we need a better understanding of the problem and assert that "the specific contours of a global expansion undoubtedly will be influenced by factors that are uncertain and idiosyncratic, and will

[21] A recent declaration by the newly elected South Korean President to wean the country off its dependence on nuclear power may be challenging this longstanding position. President Moon Jae-in is calling on South Korea to cancel its new build projects and planned refurbishments, and begin a staged phased out, allowing existing reactors licences to expire without the possibility of renewal (McCurry 2017).

not necessarily reflect historical trends." They note that democratic governments have "embraced different trajectories for nuclear energy growth since the 1980s until the 2010s" making comparisons difficult (Gourley and Stulberg, 2013: 37). Their study suggests that there is more at work here than regime type and question whether governance is as significant of a variable as once thought. They posit that the prevalence of public versus private utilities may be a better predictor of the success of nuclear power programs, but note that this factor alone cannot explain the variation we see during this period of study.

Part of the puzzle surrounding nuclear development lies with how we are looking at the problem: we are often grouping certain states together that simply do not belong together. That being said, developing a typology remains difficult due to the limited number of cases. It also seems problematic to be comparing highly developed states like the US, France, and Germany to countries like China, Brazil, and India. The time period under consideration will also heavily influence how certain factors are interpreted. One must remember that the political, economic, and technological environment during the Cold War (when most of the existing 448 reactors were built) was very different from the circumstances we find ourselves in today (IAEA 2017a). This, of course, has done little to stop the literature from making these comparisons (e.g. Furhmann 2012; Jewell 2011a). More care must given to case selection in order to garner a better understanding of the problem.

Political Science and its Proliferation Obsession

It is worth noting that the study of the civilian nuclear industry is somewhat limited within the discipline of political science. It has often either been subsumed within

the security studies literature, or worse still, ignored altogether. There are notable exceptions (Nau 1974; Poneman 1982; Bratt 2012), however, when one looks to the innumerable volumes on nuclear weapons and nonproliferation the point becomes painfully clear.[22] This bias is not without its lingering effects: recent work on the potential for a nuclear renaissance often insist on linking their discussion of the potential for a commercial nuclear revival to issues of non-proliferation and disarmament (Stulberg and Furhmann 2013; Furhmann 2009; Furhmann 2012; Miller and Sagan 2009; Sokolski 2010). This Cold War-era security preoccupation tends to distract us from why countries are assessing the merits of commercial nuclear power today. While one cannot entirely discount non-proliferation concerns, they should not be at the forefront of the study of commercial nuclear power in the twenty-first century. Countries pursuing modern commercial reactors without the sensitive elements of the fuel-cycle (e.g. reprocessing and enrichment technology) force us to consider other motivations that might be at play.

Two recent works of note, (Findlay 2012; Sovacool and Valentine 2012), provide us with a strong starting point for our discussion. They will serve as a primer that helps to situate many of the key components of the discussion (the strengths and weaknesses of the discipline) followed by a multidisciplinary exploration of the other drivers that help to shape a country's policies surrounding nuclear power development. Taken together, this literature review will serve to flag key contributions from these literatures that will be

[22] John Mueller's (2010) *Atomic Obsession* provides a good account of the discipline's fixation with nuclear weapons.

used to inform the development of a new approach that better reflects the determinants of contemporary commercial nuclear power programs.

The National Politics of Nuclear Power: Economics, Security, and Governance (2012)

Benjamin K. Sovacool and Scott Victor Valentine (2012: 1) attempt to revamp what they consider to be a dated literature with a new book that explores "why nations choose to accept the risks associated with nuclear power." They claim to have established a better model for explaining why states adopt the technology, with a truly global focus. They note that their eight cases incorporate 70 percent of the world's reactors, and they purport to explore the sociopolitical, rather than simply the technical issues related to adoption of the technology (Sovacool and Valentine 2012: 5).[23] While their inclusion of non-Western states (South Korea, Russia, Japan, China, and India) over an extended period of time (from the early 1940s through to the 1970s) is laudable, their cases still only focus on Cold War examples of nuclear expansion. This will in many ways shape one of the key catalysts they identify as central to nuclear power development: "national security and secrecy" (Sovacool and Valentine: 12). They assert that the linkage between a weapons program and nuclear power development ensure that both the political will as well as the technological know-how necessary for a power program are present in a given country. The secrecy element ensures that the high costs of nuclear power development are not debated publicly or are intentionally obscured.

Were this finding simply a historical account of what led states to adopt nuclear power during the Cold War, this would be an appropriate case selection. The problem,

[23] Their cases included: the US, France, Japan, Russia (including the former USSR), South Korea, Canada, China, and India.

however, is that Sovacool and Valentine (2012: 227) suggest that their findings remain "relevant today for predicting the probability of a nuclear power program developing in a given nation."

They identify six key drivers that help to explain/predict whether a state will develop a nuclear power program. These drivers include: "(1) national security/ and secrecy; (2) technocratic ideology; (3) economic interventionism; (4) centrally coordinated energy stakeholder network; (5) subordination of opposition to political authority; and (6) social peripheralization" (Sovacool and Valentine 2012: 227). These are further shaped by what Sovacool and Valentine refer to as political, economic, social and technological (PEST) factors. They make the case that PEST factors can be seen as the dynamic element of their model; they affect the strength and influence of the six drivers, which when taken together, are necessary for a country to start a nuclear power program.

I do not dispute the relevance of these six factors. They can all play a role in shaping the development of a nuclear power program, however, some of these drivers are needlessly opaque while other important drivers seem to be ignored by their model. In particular, their national security driver is problematic in that it blends energy security (security of supply at an affordable price), with the desire for a nuclear deterrent (Sovacool and Valentine 2012: 12-16, 227). While these two concerns might fall under the broad umbrella of security, they are in fact quite different. Blending these two distinct types of security does not provide a clear account of whether both variables are in fact present in all of their cases.

One of the key strategies for achieving energy security, the need for a diversity of supply, is given only passing mention at the end of the book and appears to be an afterthought (Sovacool and Valentine 2012: 249). I would argue that in the post-Cold War period, a state interested in developing, expanding or maintaining commercial nuclear power might be persuaded by a security of supply argument, with no explicit interest in nuclear weapons or the latent capability to develop them at a future date. While the need for a deterrent may have been a key determinant in the past, it is noticeably absent from contemporary political debates surrounding the development of commercial nuclear power in most cases.

Aside from Sovacool and Valentine's (2012) unnecessarily broad energy security variable, they seem to discount important factors like "the size of the electricity market, the size and structure of electric utilities, uranium availability, national affluence, and connectivity to neighboring electricity grids…" as being relevant to the process, but not necessary for a country to develop a nuclear power program if their six drivers are present (Sovacool and Valentine 2012: 250). This is surprising given that most other literature tends to confirm the importance of these factors as critical to determining the appropriateness of a nuclear power program for a country interested in adopting the technology (Jewell 2011a; Gourley and Stulberg 2013; Findlay 2012). While countries have ignored these requirements in the past, they have not succeeded in starting a program (e.g. Philippines).[24]

[24] The Philippines is an example of a country that ignored these technical requirements when they began construction of their first NPP in 1976. While they eventually completed construction of their first reactor, it was never successfully connected to the grid (Onishi 2012).

The model proposed by Sovacool and Valentine also fails to distinguish between the challenges of starting, versus maintaining, or expanding an existing program. In their conclusion, Sovacool and Valentine (2012: 250) concede more testing would be required to confirm whether different variables are at work in the case of a country starting a program versus reviving one that has stalled. They believe that their model would work in both cases but acknowledge that other factors might better explain the revival of an existing program.[25] I argue in this dissertation that there are in fact different drivers at work within states as they move along a continuum of possible choices as it pertains to nuclear development (whether they adopt, expand, maintain, defer, reject, or phase out a planned or existing nuclear power program).[26] This hypothesis will be tested in the subsequent chapters of this study.

Nuclear Energy and Global Governance (2012)

Trevor Findlay (2012: 1-2) sets out to "predict the likely course of nuclear energy worldwide…" through to the year 2030, by taking into account the drivers and constraints that will shape policy outcomes. While many states have proclaimed an interest in the technology, he wants to identify whether their ambitions are credible in the near term. Findlay wants to limit his study to exploring the likely expansion of commercial nuclear facilities.[27]

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[25] In the conclusion, they use the US as an example. They hypothesize that the same factors that helped to initiate the US program in the 1940s might also serve to revive it today (Sovacool and Valentine 2012: 250).

[26] The distinction may not have been as important for their work given that their focus was on historical cases of technology diffusion.

[27] This is only slightly disingenuous on his part given the amount of time he dedicates to the non-proliferation implications of reprocessing, enrichment, breeder technology, and fast neutron reactors. While these things have some commercial relevance, the discussion was not always framed in this light.

What is noteworthy about Findlay's approach is that it includes a wide breadth of states with many drawn from the Global South. Another interesting component of his study is the inclusion of a section on the global safety and non-proliferation regimes, and the stress placed on them by a potential nuclear expansion of any size.

Findlay (2012) begins by exploring the drivers behind a potential nuclear revival[28] through to the year 2030. The first chapter proceeds to critique many of the drivers identified by the nuclear industry and pro-nuclear advocates as making nuclear power an attractive option for electricity generation. Notably he criticizes the use of global projections of energy demand as an indicator of the need for nuclear power, noting the non-linear growth of energy demand, and the variations that exist at the regional and national levels not reflected in these outlooks. This of course does not prevent state-by-state analysis from being assessed, as he proceeds to do in chapter 3 of his book.

What is interesting about Findlay's assessment of the energy security argument is that he suggests that even if a state has sufficient uranium or thorium, it will still likely be dependent on nuclear technology imports of some kind from a third party. In other words, having access to fuel will not necessarily free you from requiring nuclear imports of another kind (e.g. enriched fuel, reactor technology, or key components/raw materials for an indigenous design). What remains unclear is why Findlay equates energy security with energy independence, and a concern over technology imports.

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[28] Findlay (2012: 1) prefers to use the word "revival" over the word "renaissance" asserting the latter "trivializes the serious dilemmas facing governments and others over energy and climate change policies that may well determine the fate of the planet." Findlay wants to try to avoid provocative language that might suggest an inherent bias, and instead seeks to provide a more objective account of the likely trajectory for nuclear power through to 2030.

Findlay (2012: 13) asserts "that while nuclear power can add to national energy diversity and may provide additional energy security in the sense of relative security of fuel supply, it cannot provide the elusive energy independence." This understanding of energy security is reminiscent of what Aleh Cherp and Jessica Jewell (2011) refer to as the sovereignty definition. This perspective has been linked to the American discourse, which is often characterized as being fixated on the idea of dependence on foreign oil, and in particular, a preoccupation with the Persian Gulf (Littlefield 2013). It tends to emphasize threats posed by external actors to a critical supply of energy (e.g. a group like the Organization of the Petroleum Exporting Countries (OPEC) or Russia threatening to restrict access to supply). To mitigate the risk posed by these unreliable and potentially vindictive suppliers, a state needs to have access to alternate suppliers in order to strengthen its domestic supply. Findlay (2012) links a dependence on technology and uranium imports as limiting the value of nuclear power as a tool to mitigate energy supply issues. This problem, however, would extend to a wide array of energy sources, and is not unique to nuclear power. The interconnectedness of today's energy markets and manufacturing supply chains might prevent any country from achieving the kind of mythical energy independence that Findlay is linking to energy security. It is unclear why Findlay would dismiss the energy security driver using such a narrow approach.

In terms of climate change as a driver of nuclear expansion, Findlay provides a more thoughtful response. While acknowledging that some have made the case that nuclear power could play a pivotal role in decarbonizing electricity generation, in conjunction with a series of other carbon reduction initiatives (Pacala and Socolow 2004), he asserts that there are several reasons to reject this line of thinking. One, nuclear

power is not recognized by the climate change regime (principally the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol) as a technology that can be used to produce and sell carbon credits within the clean development mechanism (CDM).[29] Two, there are no signs of the needed level of construction at the global level for nuclear power to deliver sufficient electricity in time for it to play a meaningful role in reducing carbon emissions prior to 2050. While there is no consensus on exactly how large of an expansion would be required to make this contribution, the current pace of construction has been far slower than any estimate put forward by the literature.[30] Finally, Findlay argues that there are more cost effective technologies available for reducing carbon emissions. He asserts that even if it becomes apparent that there is a need to rapidly reduce carbon emissions, nuclear power "is simply too slow and too inflexible compared to the alternatives" (Findlay 2012: 17). In other words, this costly and increasingly unlikely scenario of a global nuclear renaissance is also a poor option for tackling the climate change problem given the market-ready alternatives.

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[29] It is worth noting that nuclear power can be used to meet a state's national carbon reduction targets. The issue is that it cannot be used to sell surplus credits to other states. This is a point of contention in the current negotiations for a successor agreement to Kyoto, and even within the EU and its floundering emission trading system (ETS). Steve Kidd (2014: 10) notes that this political divide over formally recognizing nuclear power as a low-carbon technology within the European Commission is reflection of how powerful the Green lobby has become in Brussels and the other European capitals. He argues that it is somewhat counterintuitive when one recognizes that nuclear provides two thirds of Europe's low-carbon electricity (Kidd 2014).

[30] Pacala and Socolow (2004) make the case that roughly 14.5% of global electricity production, or 700GWe of new capacity, would be needed to meet carbon reduction targets. Findlay (2012: 14) notes that this estimate may be low given that Pacala and Socolow failed to take into account that most of the world's existing nuclear capacity would be retired or near the end of its operating life by 2050.

Findlay (2012) assumes Generation III and III+ designs will principally drive the nuclear revival prior to the year 2030.[31] Over 80 percent of the current global fleet is comprised of Generation II light water reactors (LWR) based on a once through fuel-cycle (Sovacool and Valentine 2012). Generation III and III+ designs claim to be larger and more efficient than their predecessors, with a longer life span, and include passive safety features that improve their reliability in the event of an accident.[32] They boast standardized designs that will expedite the regulatory process, while reducing the cost and time associated with the construction of a reactor. The lower cost would be derived from standardized designs that would lead to economies of scale following the construction of the FOAK plants. To date, these designs have proven to be "'evolutionary' rather than 'revolutionary', [and] their performance is to date unproven…" (Findlay 2012: 20). At the time of writing, Findlay (2012) noted the large cost overruns experienced at a number of Generation III+ sites as evidence that the industry was failing early tests to build on time and on budget.

Findlay (2012) concludes that the acquisition of nuclear power may in fact be driven by political rather than economic, technical, or scientific considerations. These drivers include traditional motivators like prestige, desire to develop/modernize an economy, and nuclear hedging (Findlay 2012; Sagan 1995/96; Abraham 2006; Hymans 2006). These political drivers, according to Findlay, have been bolstered by improved public opinion of nuclear power in recent years. That being said, he cautions that this

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[31] Findlay (2012: 19) notes that "the distinction between Generation III and Generation III+ seems arbitrary and more a question of marketing than science." For a brief discussion of the different generations of reactor technology see: (EC 2015).

[32] Passive safety features do not require an operator to intervene in the event of an accident.

support is "conditional and fragile," noting that any semblance of a revival relies on a perfect safety record,[33] in conjunction with heavy government subsidies in order to make nuclear power economically viable.[34]

The second chapter focuses on the economics of nuclear power, namely construction costs, and contrasts them with other traditional baseload alternatives. Findlay (2012) notes that the industry has not built enough rectors in recent years to have the data necessary to properly assess the cost of future builds.[35] There are very few examples of operational Generation III and III+ reactors, making an accurate cost assessment difficult. The Financial Services giant Moody's has suggested that "'the ultimate costs associated with building new nuclear generation do not exist today' and that 'the current cost estimates represent best estimates which are subject to change'" (quoted in, Findlay 2012: 41).

Findlay looks at a variety of market studies (Deutch et al. 2003; NEA 2008a; Moody's Corporate Finance 2007; Keystone Center 2007; Cooper 2009) to try to give a well-rounded picture of the economics surrounding nuclear power. Many of these studies look at the US, with some analysis of new builds in Finland and Canada. Based on these studies, nuclear power proves to be costlier than its alternatives by a margin of 12-20

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[33] He notes that the issue of public acceptance is complex, citing a 2008 study (Pidgeon, Henwood et al. 2008), but does little to expand on the issue. Risk literature of this kind will be explored in greater detail later on in this chapter.

[34] There are a range of incentives thought to be necessary to make nuclear power viable that are often cited: e.g. government subsidies for nuclear power, federal loan guarantees for financing, and a high price on carbon (see for example Deutch et al. 2003). Several regulatory concessions are also seen as necessary to help expedite construction times.

[35] The final cost of building a reactor includes: "the costs of construction, financing, operations and maintenance (O&M), fuel, waste management and decommissioning" (Findlay 2012: 34). Utilities in most markets are responsible for the costs associated with nuclear fuel cradle-to-grave.

cents/kilowatt-hour (kWh) (Findlay 2012).[36] The capital-intensive nature of these projects, the slow rate of learning,[37] the long construction times, and the lack of initial success with early Generation III and III+ models make them increasingly unattractive investments. Echoing other studies' findings (e.g. Deutch et al. 2003) Findlay (2012) highlights the role of government subsidies in potentially making nuclear power a viable alternative but cautions that even with these political and economic incentives in place, they may fail to have their desired effect.[38]

The lack of a substantive price on carbon emissions in most markets has made the economics surrounding nuclear power particularly precarious. Findlay (2012) notes that the very survival of the global environmental regime remains uncertain, making any investment in nuclear power difficult. Without a stable price on carbon emissions, Findlay warns that hydrocarbons will continue to push costly low-carbon alternatives out of contention. There is also no guarantee that nuclear power would be included in any future climate change agreement. Under current European Union (EU) emissions targets and those originally set out by the Kyoto Protocol under the CDM, nuclear power is not recognized as a low-carbon technology capable of being used for gaining credits to offset

[36] These figures will depend on the market in question. The economics of nuclear power can be further hampered by a reactor's relative inflexibility. An NPP cannot rapidly adjust its production levels when there is a lack of demand.

[37] Normally as a technology matures, the costs associated with construction come down. This has not been the case with nuclear technology. Some analysts have referred to this as "learning by forgetting" (Rom 2011; Grubler 2010).

[38] For example, in the US, many of these concessions were thought to have been granted through the passage of the *Energy Policy Act* (2005), and the *Nuclear Power 2010 Initiative* but they have failed to stimulate a large increase in new nuclear construction. Construction has only begun on four units since the passage of this legislation, with an additional unit's construction restarted at Watts Bar 2. Two of those units have since been abandoned at VC Summer in South Carolina.

other carbon emissions. Recently there have been efforts to add nuclear power to the CDM[39] as a legitimate tool in the battle against climate change, however, the matter remains hotly contested.[40]

Findlay also highlights the special costs associated with nuclear technology, particularly in the case of waste management and decommissioning of reactors at the end of their operating life, as unfavourable. There remain many uncertainties due to the lack of long-term facilities in place to deal with 60-plus years of waste. While countries like Finland and Sweden are making commendable progress on plans for their long-term waste facilities, the US has done little to begin work on an alternative site for commercial nuclear waste following the 2009 decision to defund Yucca Mountain.[41] The Nuclear Energy Agency (NEA) notes that this process can take up to 30 years to get from the planning stage to completion (Findlay 2012: 58). The US has had legislation on the books mandating the creation of such a facility since 1982, with little to show for its efforts to date. It has proven difficult to overcome the political and public resistance to such a

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[39] Among EU countries there is a growing chorus of states seeking to include nuclear power as a low-carbon technology to help reach their ambitious carbon reductions targets. The European Commission (EC) has gone further, suggesting that it might provide subsidies for the construction of new plants. The EC argues that nuclear power plants should be recognized as a low-carbon technology comparable to renewable sources of energy and thereby be eligible for EC subsidies (WNN 2013; WNN 2014c). The German government has voiced strong opposition to EC subsidies being provided to NPPs and its inclusion in the CDM. Germany is one of seven EU countries that oppose the continued use of nuclear power in Europe.

[40] The 2015 UNFCCC Paris Agreement, a commitment by 197 countries to make every effort to keep a "global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius," has not actively excluded nuclear. Instead, much like the CDM, it can be included at the state level, through nationally determined contributions (NDCs) (UNFCCC 2017).

[41] The Trump Administration is in the process of revising this decision. For a brief discussion on the current state of Yucca Mountain see: (Zhang 2017).

facility. The waste problem has been highlighted as an Achilles heel for the industry for decades with little sign of abatement in most countries (Di Nucci et al. 2015).

Findlay (2012: 98) asserts that "the economics of nuclear power are the single most important constraint [on nuclear expansion] and these appear to be worsening rather than improving, especially as a result of the recent global financial and economic turmoil." It is not surprising that Findlay (2012) concludes that few reactors will be built before 2030, with only a modest nuclear expansion occurring principally in states that already possess the technology. "For the vast majority of states, nuclear energy will remain as elusive as ever and a worldwide revival implausible" (Findlay 2012: 197).

For states that already operate reactors the economics behind life extensions are a little more favorable. With most of the costs associated with an NPP coming from initial construction costs, life extensions if done right may yet turn a profit (McLellan 2008). Findlay notes that what should concern us most is the safe operation of these plants as they age. According to Findlay (2012), ensuring that there is a sufficient supply of spare parts and skilled operators needed to maintain these plants for their extended operating lives will be essential.

Findlay concludes his work with an examination of the implications of a nuclear expansion on the safety and non-proliferation regimes. Here, his work becomes indistinguishable from much of the security studies literature and its alarmist weapons obsession. This is exemplified by comments like the following: "One more significant nuclear accident, one more state that develops nuclear weapons under the guise of generating electricity or one more 9/11 but with a nuclear weapon this time, is one catastrophe too many" (Findlay 2012: 197). His conclusion continues in this vein

funneling the complexity of the nuclear industry and its commercial trade through the lens of the non-proliferation regime and nuclear weapons. He argues that a new deal must be drawn up between nuclear-haves and have-nots, in reference to the recognized nuclear weapons states (NWS) in the 1968 *Nonproliferation Treaty* (NPT) and the non-nuclear weapons states (NNWS), asserting:

> The deal for aspiring states should be: if you want civilian nuclear power you have to agree to the highest international standards for avoiding accidents, terrorist seizure or attacks and diversion of materials to nuclear weapons. The deal for existing advanced nuclear states should be: if you want the nuclear newcomers to comply with a new strengthened global regime that was not in place when you first acquired nuclear energy you have to multilateralize the fuel-cycle and ultimately disarm yourselves of nuclear weapons (Findlay 2012: 214).

While some of his work falls into the tired tropes of political science's proliferation-obsessed, American-centric approach, Findlay's work ultimately provides us with a good introduction to many of the issues explored in this dissertation. The remaining sections of this chapter elaborate on the issues not explored in sufficient detail by Findlay (2012) or Sovacool and Valentine (2012).

The Economics Behind Nuclear Power

The question of the economics behind nuclear power is often cited as key to understanding the future of the industry. Questions surrounding the costing of proposed new builds and the ability for newcomer countries to effectively scale up and rapidly deploy the technology abound (Asif and Muneer 2007; Davis 2011; Fuhrmann 2012; Cooper 2009).

The economic argument is difficult to refute; put simply, nuclear reactors have rarely been built on time or on budget. To add insult to injury, while their load factor[42] has improved over time, these numbers have been far lower than industry estimates, negatively affecting the chances of a nuclear reactor becoming profitable over its operational lifetime (Lester and McCabe 1993). Nuclear reactors are different than most traditional means of energy production (e.g. gas and coal) in the sense that most of the costs, upwards of 70 percent, come from their construction, with the remaining costs coming from fuel and general O&M costs (Linares and Conchado 2013).

In the past engineering estimates put forward by companies during the bidding process for a reactor failed to present the full costs associated with a NPP. Leaving decommissioning and long-term waste management costs aside for the moment, the construction costs for new reactors remain hazy at best. The costliest element of the process, the construction of the nuclear power plant, is either poorly understood or intentionally underestimated by engineering firms.

In many cases, reactors are FOAK designs making it difficult to assess the final cost of the project (McLellan 2008). With insufficient data (i.e. a record of success with a given design), estimates can vary wildly (Kessides 2010). The United States is frequently cited as a country with limited standardization of design, with 80 of its 100-plus operating reactors using a different design (McLellan 2008). The US Congressional Budget Office found that American reactors built between 1966 and 1986 were on

[42] Load factor can also be referred to as capacity factor. This is a calculation of power produced over the net power the plant is rated for. In other words, taking into account down time for maintenance and refueling, how much power is actually being produced compared to what the reactor would produce if it was running at 100 percent capacity all the time, under ideal conditions (IAEA 2017c).

average 200 percent over budget (Ahearne 2010). This was highlighted as a problem that led to numerous cost overruns during the first major era of nuclear expansion (Davis 2011). The nuclear renaissance was supposed to correct for these mistakes and seek to standardize reactor offerings in order to bring down the costs associated with new builds. To date, this has not proven to be the case.

Standardizing Designs

Efforts to standardize designs have begun to limit reactor offerings in recent years but have not necessarily brought down costs associated with nuclear power. Some of the more well-known designs include: Toshiba-Westinghouse's AP1000, Korea Electric Power Corporation's (KEPCO) APR-1400 (Advanced Power Reactor), Areva's EPR (Evolutionary/European Pressurized Reactor), Areva-Mitsubishi's Atmea I, GE-Hitachi's ABWR (Advanced Boiling Water Reactor), Candu Energy's EC6 (Enhanced Candu 6), and variants of Rosatom's VVER-1200 series. With the exception of the EC6, these are relatively large 1000MWe-plus designs.[43]

Issues with a FOAK design have been exemplified by the difficulties AREVA has encountered building EPRs in both Finland and France. In both cases, the reactors are roughly 80% over budget and several years behind schedule (Locatelli and Mancini 2012). FOAK issues in these cases included a degree of relearning for the architect-engineer, while reestablishing a reliable supply chain that included subcontractors capable of providing the high-caliber components and labour needed to complete these complex designs (ibid.). Regulators also faced challenges associated with assessing the

[43] A MWe refers to megawatt electric. It is a standard measurement used to describe the output of a power plant.

safety of these new and untested designs. In the case of Finland, the EPR at Olkiluoto was the first design that the Finnish Nuclear Regulator had reviewed in over 30 years (Thomas and Hall 2009). Giorgio Locatelli and Mauro Mancini (2012: 633) assert that cost estimates for EPRs "have been too optimistic" when compared to reference reactors built in France and Germany. Given that Areva knew it would have to rely on an inexperienced supply chain, building a larger and more complex design, their targets were unrealistic and ultimately unachievable.

Since 2003, it has been argued that a nuclear renaissance would be difficult to achieve without a substantial price being levied on carbon or a substantial drop in the price of reactors (Deutch et al. 2003). It has been argued that reactors would have to come down in price by at least 20 percent to be competitive with coal and gas-fired plants (Joskcow and Parsons 2009).[44] Securing generous financing terms, loan guarantees, and fixed prices on reactors would be the only way for reactors to become competitive. This assumed that construction delays and technical problems could be overcome in the near term. More than 10 years after MIT first issued this report (Deutch et al. 2003), reactors' construction costs have tripled, and no stable price on carbon has been established in most markets (Bradford 2013). In the US, estimates for overnight costs[45] for new reactors

[44] Low natural gas prices make these estimates fairly conservative.
[45] Overnight costs refer to a methodology for how to calculate the capital costs (labour and materials) associated with the construction of a plant. Overnight costs are then presented as a cost per-installed kilowatt. They tend to exclude financing costs and the potential for cost escalation (Findlay 2012; WNA 2017d). Critics of this approach note that, given that a reactor cannot be built overnight, this methodology underrepresents the true costs of reactor construction (Findlay 2012; Cooper 2009).

from 2003 to 2009 have increased from $2000/kW to $4000/kW,[46] with some sources suggesting $6000/kW might be more realistic (Deutch et al. 2009; Thomas and Hall 2009).[47] While all large scale-construction costs have gone up during that period, overnight costs for coal and natural gas remain much cheaper relative to nuclear power (Deutch et al. 2009).

Peter Bradford (2013), a former member of the US Nuclear Regulatory Commission (NRC), notes that even with many of these generous conditions afforded to the nuclear industry in the US through the passage of the *Energy Policy Act* (2005), and the *Nuclear Power 2010 Initiative*,[48] only 2 of a proposed 29 reactors are likely to be built in the near term. These reactors will benefit from a 1.8¢/kWe production tax credit (PTC) for the first six reactors built (up to 6000MWe) for 8 years of production, as well as loan guarantees of up 80% on capital costs following commission, up to a maximum of $18.5 billion (Finon and Roques 2008). It is assumed that these subsidies for the first handful of new reactors in the US will allow engineering firms to rebuild their supply chains, retrain their workforces, and work out the kinks needed to bring down the cost of nuclear to a market-competitive price. In other words, these kinds of initiatives are premised on the idea that the nuclear industry does in fact experience 'learning-by-doing'

[46] kW refers to kilowatt, another standard measurement of electrical power. There are 1000kW in a megawatt (MW), and a 1000MW in a 1 gigawatt (GW). In this case given that it is a reference to overnight costs it refers to the cost per-installed kilowatt.
[47] In the case of Ontario, Moody's forecast was $7500/kW for a new build at Darlington (quoted in Findlay 2012: 41). Ultimately this was fairly close to Areva's bid of $23.6 billion for two 1600MWe EPRs, or roughly $7375/kW (Hamilton 2009b). The Ontario bids attempted to better reflect the all-in costs of nuclear as requested by the tender. Perhaps it is not surprising that these proposed reactors have since been abandoned in favor of refurbishing existing capacity at Bruce and Darlington (WNA 2017f).
[48] For a brief description of the *Nuclear Power 2010 Initiative*, see: (US Department of Energy 2010).

when building reactors. Bradford (2013) remains skeptical that such learning will take place after years of failure to achieve so-called economies of scale. Bradford notes that only in regulated states where the taxpayer assumes the risks associated with the construction of the plant has progress been made on new builds. While in the past state run vertically integrated utilities had been able to absorb these cost-overruns, many commentators have suggested that this may no longer be the case in liberalized electricity markets where utility companies have a responsibility to provide a return on investment to their shareholders.

It is becoming increasingly apparent that new builds are unlikely to be competitive in liberalized electricity markets without substantial subsidies in the near term (Bradford 2013; Thomas 2010). Within liberalized electricity markets, uncertainty surrounding cost forecasting for new builds, and a poor track record of industry learning, have made investors and utilities leery of such capital-intensive projects. They are viewed as high risk projects with limited assurances of a secure return on investment (Roques et al. 2006).

Scaling-up the Technology and Learning by Doing

In this context 'scaling up' refers to the ability of a firm to build larger commercial reactors based on smaller designs, at a proportionate cost, in a relatively short period of time (Davis 2011). Arnulf Grubler (2010) describes the process of scaling-up a technology as a process that requires a state/firm to grow a technology in a manner that allows it be rapidly deployed in a systemic fashion and on a large scale.[49]

[49] Gruber (2010) defines systematic fashion in this context as creating the complete suite of technologies and associated industries needed to build and operate the technology.

This model relies on the industry maturing along a particular trajectory. This line of thinking is premised on the learning-by-doing literature (Joscow and Rozanski 1979; Zimmerman 1982; Lester and McCabe 1993).

In the context of nuclear power, much of the early literature on 'learning' focused on the operator to gain a better understanding of how the industry was performing. This was measured in terms of capacity (or load) factors of nuclear fleets (Joscow and Rozanski 1979; Zimmerman 1982; Lester and McCabe 1993). The IAEA defines the capacity factor of a reactor as "the actual energy output of an electricity-generating device divided by the energy output that would be produced if it operated at its rated power output…for the entire year" (IAEA 2017c). Ideally a reactor is available to run as a baseload option for a utility virtually all of the time as reliably as possible, limiting the number of unplanned outages through proper operation and maintenance.

Unfortunately, during the 1970s and 1980s US NPPs had a very poor performance record. US reactors came from four major nuclear suppliers: Westinghouse, General Electric, Babcock & Wilcox, and Combustion-Engineering,[50] which included both PWR (pressurized water reactor) and BWR (boiling water reactor) designs. This diverse reactor fleet was in turn owned and operated by more than 40 utility companies (Lester and McCabe 1993: 420). Not surprisingly, they had relatively low average capacity factors stemming from operators' limited experience with any single design, and the limited information on best practices being shared by utilities with one another. The US nuclear fleet in 1991 had an average capacity factor of only 68 percent (Nuttall and Taylor

[50] Combustion Engineering's nuclear division is now owned by Toshiba-Westinghouse.

2008).[51] At the time, it was suggested that learning rates improved for an operator if they had multiple reactors at a single site (Lester and McCabe 1993). If an operator had five plus years of operating experience with a given design, it would also serve to improve the reliability of the next reactor (ibid.). In short, if a vendor could convince a utility to build multiple reactors at the same site of the same class, it would likely lend itself to improved performance of those units over their respective lifetimes.

In the case of construction costs and build times, it was expected that increased experience with the technology would lead to better results for engineering firms. The US had been the first market to experience a nuclear scale-up from demonstration units to commercial reactors. During this initial construction period, it proved difficult to accurately forecast the cost of larger commercial designs. Larger units required mechanical cooling towers not used in smaller designs along with longer than expected build times (Zimmerman 1982). As a result of these unexpected modifications to the cost of inputs, reactors were over budget by large margins (ibid.).[52]

While American firms were unable to lower construction costs, it was thought that these early experiences would lead to an improved understanding of costs and reduced errors when it came to forecasting the final price of future reactors. The limited learning in those early years, for Zimmerman (1982), had much to do with the immaturity of the technology. Zimmerman asserts that the technology was still in a transition phase

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[51] This is a modest improvement from 1980 when it was only 60%, with a 55% average among designs of 800MWe or larger (Komanoff 1981).

[52] It is interesting to note that reactors costs were never under-estimated by the vendor. From 1975 to 1978 Zimmerman (1982) notes that reactors were over budget by an average of 95 percent. As noted above, the Congressional Budget Office found that reactors built from 1966 to 1986 were on average 200 percent over budget (Ahearne 2010).

from demonstration to commercialization. The rapid scale-up of the technology in the US allowed a young technology to mature, albeit with large cost overruns and long construction delays. It was expected that the next generation of reactors would benefit from these early experiences and improved cost forecasting.

It was noted by many studies at the time that larger reactors had serious performance issues throughout the 1970s and early 1980s (Komanoff 1981; Lester and McCabe 1993; Joscow and Rozanski 1979; Bupp and Derian 1978). This again comes back to the maturity of the technology. The scaling-up of the technology from demonstration reactors to commercial plants in the 1970s was staggering. Zimmerman (1982) highlights the relatively rapid growth of demonstration units, ranging from 40 MWe to 575MWe, during the 1950s and early 1960s. By contrast the smallest commercial reactors being built by 1969 were starting at 500+ MWe. By the late 1970s firms were building 1100+ MWe designs (IAEA 2017a).

The American experience was marred by the poor performance of its fleet, long construction delays, and cost overruns. It took until the 1990s for signs of improvement in the industry to signal that nuclear power might finally be ready to effectively challenge traditional fossil fuels.[53] The challenges associated with being the first country to commit to a commercial-scale nuclear power program were steep; it would be less onerous for those that followed the United States down the nuclear rabbit hole, and yet as we will see in the next section, learning does not occur as easily as the literature might suggest.

[53] Nutall and Taylor (2008) note that the consolidation of the industry (amongst its operators) in conjunction with investments in uprates and refurbishments led to greatly improved performance from the US nuclear fleet. The average capacity factor rose from 68 percent in 1991 to 90.7 percent in 2001 (Nutall and Taylor 2008: 8).

The French Case

The French case has always been thought of as a successful case of scaling-up nuclear technology. They were able to rapidly establish a program consisting of 58 reactors, amounting to over 75% of their electricity generating capacity, in a relatively short period of time (from 1970-2000). Much of this success was linked to their decision to use a standardized design based on a Westinghouse-licensed PWR (Grubler 2010). It was argued that the French had learned from the American experience and as a result selected a single reactor design, under the umbrella of a large state-run utility (*Électricité de France* or EDF), using multi-unit sites, which allowed for the greatest degree of learning (Lester and McCabe 1993). It helped that the state in conjunction with a tightly knit group of state-owned entities including Framatome (today known as Areva), the engineering giant responsible for building the reactors, the *Commissariat à l'énergie atomique* (CEA), the research and development arm of the government and the regulator, *Autorité de sûreté nucléaire* (ASN), worked closely with one another to rapidly scale-up the technology. The state-run centralized approach to nuclear power along with their strong managerial competence was thought to have helped the French program immensely (Jasper 1990; Jasper 1992).

Standardization: An Oversimplification?

During the French nuclear scale-up, the original 900MWe PWR design was progressively modified and enlarged. During this period, 54 of the 58 reactors built in France used a Westinghouse licence that ranged in size from 900MWe to 1300MWe

(Roche 2011).[54] The new designs may have improved safety but the loss of standardization led to a longer construction schedule. Each modified generation of French PWR increased the construction time and cost per unit built.

Grubler (2010) argues that the goal of standardization was supplanted in favor of designs that increased safety, efficiency, and capacity. These changes made it difficult to apply a simple learning curve to the French case, which assumes lower construction costs over time as a firm gains experience with a given technology. In this case, the French were experiencing a negative learning curve, dubbed by Grubler "forgetting by doing." The increased complexity of the French reactors over time hindered learning from one iteration of PWR to the next (Grubler 2010). Ultimately, the N4 version, the last iteration of the French PWR, cost 3.5 times more than the first, the CP0 PWR (Grubler 2009: 26).[55]

Grubler (2010) argues that this is more than simply a question of increasing regulatory demands and growing public opposition. An inability to accurately forecast costs appears to be a problem for complex systems, no matter how mature a technology is (Grubler 2010; Davis 2011; Taylor et al. 2008).

In essence, the industry is left in a precarious position. Historically it has been unable to build reactors on time or on budget. The literature had long assumed that

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[54] It is interesting to note that Lester and McCabe's (1993: 426,433) analysis was limited to 28 reactors in France that were in operation by early 1985. As a result, they only looked at the 900MWe PWRs built in France. Their analysis did not include larger designs that were under construction at the time. Davis (2011: 16) cites this study when he looks at France as a successful case of learning by doing.

[55] According to Grubler (2010: 5182-5183) "the unsuccessful attempt to introduce a radically new, entirely French design towards the end of the program (the N4 reactors) that did not allow any learning spillovers in design or construction," proved to be the most problematic of all, in terms of cost and build times.

standardization, in conjunction with a stable regulatory environment and more authoritarian or centralized decision-making approach, would lead to lower costs (Thomas 1988; Slovic 1993; Campbell 1988; Jasper 1990; Jasper 1992). Unfortunately, as we have seen, even in cases where many of the above criteria were met, cost escalation and long construction times followed.

The Current State of the Industry

Concerns over the nuclear industry's ability to learn from its past experiences and bring down the costs associated with standardized Generation III+ designs during the nuclear renaissance appear to have been well warranted. Earlier this year, Toshiba-Westinghouse had to write down $6.3 billion in losses associated with the four AP1000 units being built at Vogtle and V.C. Summer. In March 2017, Westinghouse Electric, the division responsible for building the reactors filed for Chapter 11 bankruptcy. On July 31, 2017, Santee Cooper and SCANA announced that they would be abandoning construction of the two units at V.C. Summer. Costs associated with the project, a twinned AP 1000 plant, had ballooned from $11.5 billion in 2008 to $25 billion in 2017 (Bade 2017). Timelines for the completion of the plant had already been extended by two to three years for each unit before the announced cancellation. It now seems likely that South Carolina ratepayers will be stuck paying for a plant that will never be completed (Maloney 2017b).[56] The Vogtle project, another twinned AP 1000 NPP, is facing similar cost overruns and delays, however it is still expected to be completed (Bade 2017; Walton 2017).

[56] The utilities will attempt to recover damages from the supplier, however, it remains unclear just how much they will be able to extract from a financially hobbled Westinghouse (Maloney 2017b).

Prior to the bankruptcy announcement, Toshiba-Westinghouse was considered a global leader in the nuclear reactor business with their designs in use around the world. Toshiba is now in the process of restructuring itself to protect the parent-company from the multi-billion-dollar financial fallout associated with Westinghouse (Maloney 2017a; Bade 2017). Poor performance in the US, along with the company's ongoing financial difficulties are likely to limit its ability to remain competitive in the global nuclear exports market moving forward.

Similar challenges are facing the French nuclear engineering firm Areva,[57] who are experiencing a €5.3 billion cost-overrun and an almost 10-year delay at their new build project in Finland (Ward 2017). Areva has recorded losses of more than €7 billion since 2014, forcing the French Government to step in and restructure the company (Stothard and Ward 2017). Restructuring will allow the government to buy out minority shareholders in the company and provide a €4.5 billion aid package to the troubled reactor division. EDF will take a majority ownership stake in the newly formed New NP (WNN 2016B; De Clercq 2017). "Unlike Toshiba, EDF says it is determined to push ahead with its international nuclear new-build strategy, seeing it as a way to leverage France's historic expertise in reactor technology and diversify away from an increasingly competitive domestic market" (Inagaki et al. 2017). However, given their poor performance at home and abroad, it is unclear just how competitive New NP will be.

Given the financial difficulties that have plagued Western suppliers like Areva and Toshiba-Westinghouse, it is expected that developing countries will now turn to

[57] Areva is the French state-owned enterprise responsible for building the country's nuclear fleet. They are currently building reactors in China, Finland, and the United Kingdom (UK).

Russia and China for nuclear exports (ibid.). Mark Hibbs (2017) notes that Chinese and Russian state-owned corporations appear "immune to and poised to capitalize on the problems that have beset Western firms…[with] big plans to aggressively export nuclear power plants" to more than 20 countries. With strong government support, they are uniquely positioned to offer generous financing arrangements for new builds that cannot be matched by Western countries bound by OECD export credit rules (ibid).[58] Michael Shellenberger, president and founder of Environmental Progress, asserts that the US, France, and Japan are simply no longer competitive in the nuclear exports market. This leaves Russia, China, and South Korea as the only viable options for countries interested in new builds (Inagaki et al. 2017).[59] State corporations, like Rosatom and China General Nuclear Power Group, operate by different rules and are not necessarily bound by the rules laid out by market economies. They are likely to be the only kinds of companies that can bear the economic risks associated with NPP construction in the twenty-first century.

The economics literature highlights some of the more obvious barriers for states interested in new builds given the capital-intensive nature of the technology. It raises questions of financing, performance of the technology when compared to rival energy sources, poor cost estimates, and the potential for cost overruns on a variety of fronts due to a poor track record of learning with what was assumed to be a mature technology.[60]

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[58] Export credit rules place restrictions on the terms OECD member countries can offer for financing in support of their exports. It is meant to discourage unfair trading practices.
[59] Given South Korea's recent move towards a nuclear phase out, their future as a nuclear exporter may not be as bright as once thought. For a good discussion on the future of nuclear exports and the rise of China and Russia see: (Hibbs 2017).
[60] The negative learning curve thesis advanced by Grubler (2010) has been challenged by Lovering et al. (2016) who argue that a more complete data set that includes reactor

This has long been a criticism raised by opponents of nuclear power (see for example Lovins 1986). What the economics literature fails to explore are the social constraints countries still face when looking to build and operate a reactor.

Questions of Risk and Social Acceptance

The word "nuclear" is rarely associated with positive imagery. It brings to mind nuclear accidents at Three-Mile-Island, Chernobyl and Fukushima, as well as concerns over proliferation to countries like Iran and North Korea. Therefore, it is not surprising that the public's perception of civil nuclear power tends to be unfavourable. In an industry where few reactors have ever been built without some form of government financing, (Feiveson 2009) public opinion plays a deciding factor in determining the viability of a project. Increasingly the language of 'social license to operate' is linked to the idea of nuclear development, and is regularly invoked by the industry itself (see for example, Bruce Power 2015c). The former President and Chief Executive Officer (CEO)

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construction history from around the world (e.g. Canada, West Germany, Japan, India, and South Korea) in addition to France and the US would paint a much different picture. Lovering et at. (2016: 380) conclude that the US and France are "not necessarily the best or most relevant examples of nuclear cost history" given their unique experiences and large cost-overruns when compared with other states. They suggest that there is no single learning curve fore nuclear power and that other factors should be considered when modelling future cost projections. Their study has been heavily criticized for cherry-picking data, focussing on overnight costs which "substantially underestimates the effect of cost escalation over time" and conclusions that do not accurately reflect the data used (Koomey et al. 2017: 642). Gilbert et al. (2017) note similar concerns over quality of the data used in Lovering et al. (2016) and the conclusions they derive related to cost escalation and learning. Lovering et al. (2017: 653-654) have responded to these critiques, acknowledging the need for more "accurate and representative data…[to] explore the diversity and complexity of nuclear cost experiences more rigorously, in service of better understanding the primary drivers of nuclear costs and the optimal institutional arrangements and policies that might reduce nuclear costs and construction times."

of Canadian Nuclear Laboratories (CNL),[61] Dr. Robert Walker (2014: 65), has asserted that "This is perhaps the greatest challenge in the on-going quest that we have: to build and sustain public confidence and trust in our industry, to provide us with the social license to realize the full promise of nuclear technology for the world." To unpack this line of thinking it is necessary to explore the risk literature, which has spent a considerable amount of time exploring themes related to the social acceptance of nuclear power.

Understanding Technical Approaches to Risk: Probabilistic Safety Assessments (PSA)

Within the nuclear industry, expert risk assessments are a key element of the licensing process to determine the safety case to build and operate an NPP. This type of risk assessment is referred to as a Probabilistic Safety Assessment (PSA).[62] A PSA is meant to identify "the events and their combination(s) that can lead to severe accidents, assessing the probability of occurrence of each combination and evaluating the consequences" (Verma et al. 2010: 323). This kind of modeling is meant to help better inform regulatory bodies and utilities of the safety of their plants, and the risks associated with any number of design-basis and non-design basis risks. PSAs were first used during the Second World War within the US Air Force, and later the American space program but have since found wider application across a variety of industries. In the case of the nuclear industry, they became prominent following the 1975 *WASH-1400 Reactor Safety Study*. Sponsored by the US NRC, the American nuclear regulator, it was an attempt to

[61] CNL has inherited the research arm of Atomic Energy of Canada Limited (AECL), the former Crown Corporation charged with nuclear research and development in Canada. CNL will be discussed at greater length in the chapter on Canada.
[62] Also known as a Probabilistic Risk Assessment (PRA).

identify the possible risks associated with operating a NPP, the likelihood of those risks, and the possible consequences that would follow in the event of an accident. Norman Rasmussen, WASH-1400's principle investigator suggested: "the objective of the study was to make a realistic estimate of these risks and, to provide perspective, to compare them with non-nuclear risks to which our society and its individuals are already exposed. This information may be of help in determining the future reliance by our society on nuclear power as a source of electricity" (Rasmussen 1975: 1). Put simply, this approach to risk identifies the probability of an accident and the likely consequences it might pose to the public if it were to take place (e.g. fatalities, injuries, property loss, and potential environmental damage). This type of analysis allows comparison of both man-made and natural hazards. For example, it allows us to calculate the likelihood of being killed in a car accident and compare it with the odds of being killed in an extreme weather event like a tornado. This type of probabilistic analysis also helps to identify vulnerabilities of a NPP arising from its location or current/proposed operating practices. This can help a regulator to flag the limitations of existing emergency operating procedures and accident management programs for an operator in order to improve the overall safety of a proposed or existing NPP (CNSC 2014a).

Given the low frequency of nuclear core meltdowns, it is not surprising that PSAs have shown nuclear power to be relatively low risk when compared to many other hazards.

The Psychometric Paradigm

This probabilistic understanding of risk was found to be at odds with how the public tended to assess hazards in their day-to-day lives. One of the pioneering

approaches to risk perception is based on the psychometric paradigm, which established a cognitive map to help explain how an average person might assess risk (Starr 1969; Covello 1983; Fischhoff et al. 1978; Slovic 1987).

Unlike expert risk assessments, usually based on annual mortality rates, the average individual is thought to perceive risk differently. It is thought that they use heuristics to simplify otherwise complicated assessments of an uncertain hazard to make their world more manageable. They assess the voluntariness of the risk, the perceived benefit, the level of familiarity, and the potential for catastrophe in order to determine the threat posed by a given hazard (Slovic 1987). Nuclear power has the unfortunate distinction of being associated with almost all of the characteristics related to high risk with limited perceived benefits to society (Slovic et al. 2000). The psychometric paradigm literature notes that both experts and lay people tend to have an unwarranted degree of certainty and confidence in their beliefs, and as a result these beliefs are insensitive "to the tenuousness of the assumptions on which their judgments are based…", making their beliefs difficult to change once they have formed (Slovic et al. 2000: 109). In other words, experts and the general public alike are often blind to the shortcomings of their positions on risks making reconciling these differences all the more difficult.

The aforementioned conception of risk, based on the psychometric paradigm, has come under attack from various corners. Harry Otway and Kerry Thomas (1982) see this approach as adopting a technocratic bias that tends to assume the public is simply misinformed and lack the necessary information to properly assess a given hazard. Otway and Thomas (1982:75) complain that there is an underlying paternalistic tone to this kind

of work that "is predicated on the idea that only one of these views is correct [that of the expert], and the rest can and should be changed." In other words, the public simply misunderstood what should be seen as objectively low risk activities and technologies, and this can be corrected for by providing them with the appropriate information.

Harry Otway and Brian Wynne (1989) argue that this technocratic bias has been the basis of risk communication since its inception. It tries to reduce risk to simple mathematical calculations and explanations of probability regarding expected annual fatalities; it assumes a generalizable understanding of risk can be deduced, one that is impervious to social and political context. This has fostered a type of risk communication that is one-sided and fails to seriously consider what the public thinks about a given issue or the context in which they find themselves in (Otway and Wynne 1989).

The Public Deficit Model and NIMBY (not-in-my-backyard)

These technocratic assumptions form what is known as the Public Deficit Model. It is premised on the assumption that the public's understanding of an issue (or technology) is based on "too little, or incorrect information" (Burningham 2000: 57). Experts assume that the public is responding negatively to a technology due to a lack of accurate (technically-based) information and as a result they misunderstand the contours of that risk. Within this paradigm, it is thought that this misunderstanding of risk can be corrected for if the public is educated on the technical benefits of the technology and the limited objective risk it poses to their overall safety. It is premised on the assumption that, if given the opportunity, the scientific community will be able to properly inform the public and give them a more objective understanding of risk based on scientific/technical knowledge. "From this perspective, fears or opposition to scientific or technological

innovations could be explained simply in terms of public ignorance of the science and thus could be overcome with sufficient information or education" (Burningham et al. 2014: 247). This line of thinking has been linked to the not-in-my-backyard (NIMBY) catch-all critique of those opposed to nuclear power. All too often it is assumed the public's opposition to the technology is rooted in an illiteracy of the technical benefits of nuclear power. NIMBY opposition was frequently cited in the interviews I conducted for this study as one of the core social barriers to the political acceptance of nuclear power. NIMBY as a term is defined by the literature as:

> A pejorative shorthand to denote irrational, selfish, and obstructive individuals who fear change and stand in the way of essential developments. NIMBYs are considered parochial individuals who place the protection of their individual interests above the common good (Burningham et al. 2014: 247).

Opponents of nuclear power within this paradigm are framed as irrational, misinformed, emotional, or worse still, simply self-interested and selfish. NIMBY was originally coined by policy experts and sociologists who were seeking to decipher public opposition to the siting of facilities that might be otherwise seen as necessary for a community, but objectionable if located near a particular neighborhood (e.g. a city dump, a prison, or a homeless shelter) (Dear 1992; Freudenburg and Pastor 1992). "Residents usually concede that these 'noxious' facilities are necessary, but not near their homes" (Dear 1992: 288). Thus, opposition in this context is seen as a special interest group holding the public good hostage, and preventing the construction of necessary facilities for the broader community (Gibson 2005).

The implicit argument is that if viewed objectively, a rational, informed person would see the necessity of these projects and not object to them, even if they were being placed in their backyard. The Public Deficit Model is invoked when it is assumed that

this opposition can be overcome through a one-way technocratic discussion used to inform the public and to help neutralize opposition to a given project. Wynne (2001) suggests that this type of thinking is pervasive within the scientific community and that it is problematic because it serves to alienate the public that they are trying to reach. More troubling for Wynne is that the scientific community is seemingly uncritical of its own assumptions regarding the 'good' being put forward as objective and in the best interest of the community. "The embedded assumption was that no rational and properly informed person could possibly disagree with the desirability of whatever science endorsed – nuclear power, chemical pesticides…genetically modified (GM) crops and foods" (Wynne 2006: 215). Wynne argues that as a result of this misguided strategy, public hostility and mistrust of expert opinion is on the rise. The public in these cases is not misunderstanding the risks associated with a technology, rather, they are rejecting the institutions that promote it and the coterie of experts they perceive to have failed to protect them from it in the past.

Wynne (2001) asserts that the concerns the public raises about a given technology cannot simply be dismissed as irrational and emotional. Instead, for Wynne the onus is on the scientific community to make a better case for the need for a given risk, and why a technology or the use of a specific site is a good option for a community rather than characterizing it simply as a necessity. This critique highlights the politicized nature of knowledge and challenges posed by claims of objectivity when it comes to scientific knowledge. In the pursuit of scientific knowledge we regularly limit our focus, carefully select our variables, and narrow the parameters of our study in order to reach certain outcomes. The scientific community must be ready to acknowledge that in removing

complexity from the world, they are seeking knowledge for a particular aim. Wynne (2009: 204) asserts that "we're not doing it just because we want to know…it's not just innocent knowledge," there is more at work here. He acknowledges the benefits of a positivist approach to knowledge accumulation, but calls on the scientific community to be aware of the biases and limits implicit in this epistemological model rather than uncritically insisting on its objectivity (Wynne 2009; Wynne 2011).

The persistence of this paradigm (the knowledge deficit model) and the scientific community's intransigence on this issue when communicating with the public does little to inspire confidence that trust can be restored in the nuclear industry and the regulatory bodies charged with protecting public safety.

Loss of Public Trust: Democratic Engagement and Social Licence to Operate

Technocratic risk communication emanating from industry-insiders and regulatory bodies has come under increased scrutiny following catastrophic industrial accidents and technological mishaps like Bhopal and Chernobyl (Otway 1987). Critics of this form of risk communication suggest that the public no longer trusts industry or government to do what is in the public's best interests as far as technology is concerned (Campbell 1988). This has given rise to more democratic approaches to communication that call for greater consultation with the public. This includes creating a space for non-expert conceptions of risk (Otway 1987).[63] Democratic engagement initiatives are meant

[63] As an interesting counter-point to this line of thinking, the more technocratically oriented psychometric paradigm literature suggests that this form of communication may not be possible unless trust can be restored between the public and the expert-community (Slovic 1993). The problem has been that trust has proven fragile and much more difficult to restore once it was broken than it was to gain in the first place. Slovic (1993) refers to this social phenomenon as the "asymmetry principle." He suggests that, "when it comes to winning trust, the playing field is not level. It is tilted towards mistrust" (Slovic

to legitimize the concerns of the public, providing room for a dialogue between experts and the broader public in order to better manage the emergence of modern technological risks.

This gives rise to notions of democratic control of technology, an effort to engage with the public to determine how a new technology ought to be used within society. "It is…about rethinking social arrangements, about a reassessment of intentions and achievements of modernity−all of which deserve democratic debate" (Hajer 1995-1996: 34). In the case of nuclear power, while previous decisions had been made between the regulator and the industry, it is now argued that room needs to be made for the public's concerns to be heard. The public is now seen as a relevant stakeholder that needs to be consulted during policy debates rather than marginalized and placated (Otway and Thomas 1982). It is a democratizing process that attempts to strip the debate of its existing power structures to create a space for actual discussion and debate on a given issue. Timothy Gibson (2005: 397) argues that more egalitarian discussions over the public good and the appropriate use of a technology would require "a *truly* contested political field. [The challenge]…is to create a local public sphere where all claims to represent the public interest are advanced, challenged, and legitimated within a vigorous debate—a debate marked by an equitable distribution of economic, political, and symbolic power." In theory, this approach is quite alluring but in practice it can be quite difficult to operationalize as we will see in the subsequent chapters.

1993: 677). Public opinion is distorted by the increased visibility and higher degree of importance placed on negative events. In addition, bad news tends to be viewed as more credible than good news, with future negative events likely to reinforce and perpetuate these already poor views regarding the management of a given risk (or in this case an industry).

In the case of the nuclear industry, it has become increasingly apparent that there is a need for social engagement with the local community in order to continue to operate effectively within democratic societies. As noted earlier, the language of social licence to operate (SLO) has become common parlance within industry publications and press releases (see for example Bruce Power 2015).

Borrowing from Corporate Social Responsibility (CSR), it broadly refers to the consent of the local community to conduct business there (Parsons and Moffat 2014). SLO is seen as program that involves a high level of engagement with the local community, to build a lasting relationship – one that emphasizes transparency, trust, and credibility (Prno and Slocombe 2012). In essence, they are trying to establish effective and cordial relationships with the local stakeholders in order to become a welcome and respected member of that community. This ongoing collaboration and gradual integration within the community is thought to provide a higher degree of certainty to investments when dealing with potentially controversial projects in the energy sector (e.g. mining projects, pipelines, and NPPs). SLO encourages companies to go above and beyond the mandated regulatory requirements to ensure that such a relationship is nurtured and maintained (Nelsen 2006; Prno and Slocombe 2012). Examples include investments in community infrastructure, hiring practices that benefit the local community, and strong indigenous engagement. The uranium mining company Cameco is frequently touted for their extensive CSR work which extends to SLO. They view this kind of work as essential to their success (Cameco 2012). It has come to be seen as a necessary component of doing business in the nuclear sector.

The Compatibility of Increased Public Engagement with Nuclear Power Development

This shift in thinking regarding what is necessary in terms of public engagement may make the process for approving projects that much slower and costlier. What is politically expedient and commercially advantageous may not be congruent with what is democratic and transparent (Slovic 1993). There is evidence to support the idea that the most rapid nuclear expansions have taken place using a more authoritarian, centralized, technocratic approach to governance (Thomas 1988; Slovic 1993; Campbell 1988; Jasper 1990).[64]

In James Jasper's (1990: 179) study of the politics behind nuclear energy he notes that governments and the nuclear industry tend to reject the anti-nuclear movement as "irrational or uninformed." In the US, France, and Sweden, nuclear expansion historically took place largely behind closed doors without any serious public scrutiny. "Policymakers had real flexibility, genuine choices to make," when it came to nuclear power early on because these kinds of discussions and efforts to engage with the public were not seen as necessary (Jasper 1990:184). Given the technocratic and political consensus at the time surrounding the safety and reliability of nuclear power there was little reason to oppose it (Morone and Woodhouse 1989). "The low level of [public] participation in the debate in the early years reflected the high degree of consensus on the issue: very few outsiders criticized what was going on" (Morone and Woodhouse 1989: 120). Paul Slovic (1993) credits the success and expedience of the French program with its governance structure. Their approach limited public input and centralized control

[64] This fits well with the secrecy component of Sovacool and Valentine's (2012) national security driver.

allowing the French government to pursue its favored policy relatively unabated (Slovic 1993; Jasper 1990; Jasper 1992).

This freedom and flexibility over energy policy disappeared under public scrutiny over safety issues and fiscal responsibility following major nuclear accidents and economic recessions during the 1970s and 1980s (Jasper 1990; Morone and Woodhouse 1989). Accidents at Three Mile Island and Chernobyl confirmed the public's suspicions about the technology and its potential for catastrophe, cementing public opinion against the technology and its widespread use in many countries. John Campbell (1988) suggests that nuclear expansion may require limited public involvement in order to succeed. "Given the mistrust of the technology itself…it may be that…democratic institutions and prolonged commercial success are fundamentally incompatible" (Campbell 1988: 180).

Historically, it appears as though that the least transparent and least inclusive approaches to decision-making have been the most successful environments for the development of nuclear power programs. Increased public engagement in the development of energy policy has historically coincided with a slower approval process that has served to frustrate the development of proposed nuclear projects. Perhaps not surprisingly, social acceptance is frequently highlighted as a principle impediment to the continued development and operation of nuclear power in democratic societies. The next section will explore efforts to better understand public perception of the technology and the circumstances that might lead someone to reevaluate their preferences regarding the use of nuclear power.

Reluctant Acceptance and the Complexity of Risk

There has been a concerted effort in recent years to highlight the environmental benefits of nuclear power in the battle against climate change as a way to rebrand the technology. It is thought that if nuclear power can effectively be framed as means of achieving energy security in a carbon-conscious manner that it might prove more palatable to the public.

A recent study of the British public's feelings about energy and climate change found greater levels of acceptance for nuclear power when it was framed as a tool to combat climate change (Pidgeon, Lorenzoni et al. 2008). Researchers concluded that while this could hardly be characterized as a strong endorsement of nuclear power, it appeared as though the risks associated with climate change outweighed the perceived risks of using nuclear power for the participants (ibid.). The study found that this framing led to a "pragmatic, but nevertheless highly conditional acceptance of a mix of energy sources, including nuclear power, to reliably meet energy needs…" (Pidgeon, Lorenzoni et al. 2008: 80-1). The participants continued to prefer supply mixes that relied more heavily on renewables but were open to options that included nuclear. Nick Pidgeon, Irene Lorenzoni et al. (2008) were attempting to replicate and expand upon a phenomenon identified in an earlier study known as "reluctant acceptance" (Bickerstaff et al. 2008). Both of these studies were attempting to test the effectiveness of the counter-frame being employed by the nuclear industry and the British Government that was presenting nuclear power as a necessary tool in the battle against climate change. While participants placed a high degree of trust in scientists and the possibility of a technological solution to climate change, they were far more critical of their government

and the perceived level of competence they had to deal with such a complex problem (Bickerstaff et al. 2008). There was a deeply held skepticism that the government was in fact acting in the public's best interests. Participants challenged the notion of the simplistic trade-off between the use of nuclear power and a reduction in greenhouse gases (GHGs), viewing it as an oversimplification of a complex problem. The government in these studies was seen as an unreliable interlocutor potentially beholden to industry and other special interests whose rhetoric on the issue was seen as manipulative. Within this context, it was suggested that nuclear power was at best a bridge technology for the United Kingdom (UK) rather than a long-term solution (ibid.). Far better stakeholder engagement would be required to build the trust needed to mediate public concerns surrounding nuclear power.

In a similar study conducted in the US, respondents were found to be more likely to see nuclear power as a viable energy alternative when it was framed as means of addressing power shortages rather than climate change (Whitfield et al. 2009). Participants nevertheless remained "ambivalent" about the option (ibid.).[65] Similarly, in Switzerland, while support for nuclear power was strong when framed in terms of energy security, only 42 percent "of respondents…[believed]… that existing nuclear power plants play [a role] in reducing carbon dioxide emissions" (WNN 2014f). In all of these studies, when nuclear power was framed as beneficial, either as a means of achieving

[65] Stephen Whitfield et al. (2009) were unable to replicate the findings of Pidgeon, Lorenzoni et al. (2008). Whitfield et al. (2009) cite a 2007 Gallup poll that found Americans concerned about climate change were highly unlikely to see nuclear power as an acceptable solution.

energy security or reducing carbon emissions, acceptance of the technology improved, but in a very conditional and limited way.

In a 2011 follow-up to the Pidgeon, Lorenzoni et al. (2008) and Bickerstaff et al. (2008) studies, it was found that individuals with high levels of concern for the environment were unlikely to support nuclear power. Those that expressed "reluctant acceptance" for nuclear power expressed "serious reservations about both nuclear power, and the either/or framing of the climate change vs. nuclear power choice" (Corner et al. 2011: 4830). Their key finding was that in order for counter-frames like climate change and energy security to succeed, participants needed to be able to express their discomfort and frustration with nuclear power as a policy option. It was seen as a solution of last resort, with 57 percent of participants expressing 'reluctant acceptance' for nuclear power as a tool to combat climate change and achieve energy security. Adam Corner et al. (2011: 4831) argue that given these findings, stakeholder engagement initiatives cannot be conducted with an aim "to impose a single or definitive framing of the issue under consideration…it is critical that such engagement is taken forward in as open and flexible a way as possible." This was a theme that emerged from my interviews in all three cases; the increasing need to listen to the concerns raised by the public in hearings, consultations, and other regulatory processes. The challenge for the nuclear industry is how to best respond to those concerns.

This literature points to the domestic context as playing a key role in determining public perception of nuclear power. The decision to adopt or reject nuclear power is not a simple one. Domestic constituencies can have varying levels of support for nuclear power based on very different metrics. "The public is as complex and fragmented as the

societies and sub-groups of people from which views are elicited. There can be no one single public opinion on the environment and risk—but a spectrum of positions, opinions and discourses" (Pidgeon, Lorenzoni et al. 2008: 82). The public needs to be able to see the benefits derived from nuclear power and weigh the risks associated with the technology against the alternatives with the ability to discuss and debate the potential outcomes freely.

Nuclear Communities: A Divergent Outlook on Risk?

It has long been assumed that nuclear communities (those that already have one or more nuclear reactors nearby) are more accepting of the nuclear industry. This acceptance is thought to extend to the continued operation of local plants and the potential for new builds in that community. It is assumed that the familiarity the public would have with the local facility, its employees, its history of safe operations, and the economic benefits it has brought to the community would shape their view of the technology. Recently these assumptions have been put to the test in the UK (Venables et al. 2009; Venables et al. 2012; Parkhill et al. 2009). New findings suggest that economic incentives do not appear to be as influential as previously thought, however, a familiarity with the local plant can lead to conditional support for the technology as a result of a normalization of the risk (Parkhill et al. 2009). This support is tenuous and subject to an "ebb and flow…[that]…highlights a transitory quality to acceptance locally" (Parkhill et al. 2009: 55). So while an NPP can become a familiar part of the local landscape that produces a sense of safety over time, local fears and insecurities can reemerge as a result of external shocks like Chernobyl or Fukushima.

While it is clear from these studies of British communities that an existing NPP can eventually integrate itself into the local landscape, this does not in turn necessarily lead to support for new builds. In an earlier study of nuclear communities, Joop van der Pligt et al. (1986) acknowledged this limitation. They found that while there was a marginally better perception of nuclear power in communities that host NPPs when compared to those that do not, that both constituencies viewed new plants as having a negative impact on the community (van der Pligt et al. 1986). So while a familiarity with a local NPP may lead to acceptance of the existing plant and the technology broadly speaking, it may not alter perceptions regarding the construction of new plants.[66] In short, the complexity of technology assessment cannot be allayed or removed simply by focusing on communities with existing nuclear infrastructure as has been the case with many planned nuclear new builds.

Nuclear Waste Management: A Key to Public Acceptance or a Sticking Point?

The risk literature calls on industry and government to build trust in communities through a more transparent process that engages with their concerns in a two-way dialogue. While there is evidence of this taking place when it comes to environmental impact assessments and the protracted political discussion on the phase out in Germany, it is perhaps best observed in the case of nuclear waste management initiatives in all three of the cases explored in this study. Following earlier efforts to limit public consultation and apply a top-down expert driven process to siting nuclear waste repositories in

[66] The authors suggest that this would apply to any new large-scale development that might be seen as disruptive to the community (van der Pligt et al. 1986). We can see this in countries like Switzerland, where the public is supportive of maintaining existing plants till the end of their operating lives but oppose new builds (WNN 2016a).

countries like the US, Canada, and Germany (Flynn et al. 1993; Hocke and Kallenbach-Herbert 2015; Durant and Stanley 2009), a new approach has had to be developed. Having learned from past mistakes, it has become the industry standard to undertake a voluntary and consultative approach to finding a socially acceptable means of waste management (Feiveson et al. 2011; NEA 2008b; Darst and Dawson 2010). This approach appears to have led to successful site selection in both Finland and Sweden.

Nuclear Waste and Deep Geological Repositories (DGRs): A Primer

The nuclear fuel-cycle produces low, intermediate, and high-level waste (WNA 2017c). Spent fuel is characterized as high-level waste (HLW). It can be reprocessed (or recycled) in order to be used again in a reactor that burns MOX (mixed oxide) fuel, however only a handful of countries have the infrastructure needed to do this on a commercial basis (Di Nucci et al. 2015). Ninety percent of the world's spent fuel is kept in interim storage facilities adjacent to the nuclear reactor where it was used (WNA 2017c). Fifty countries use interim waste facilities to manage their spent fuel, none of which have developed a final repository for their HLW that is in commercial operation (Di Nucci et al. 2015). While most of the radioactive isotopes in HLW will have decayed after the first 40 years in storage ponds (interim facilities), there are elements of the HLW that will remain hazardous to humans and the environment for tens of thousands of years (WNA 2017c).

Most countries have opted to pursue what are known as deep geological repositories (DGR) for the final disposal of their HLW. These DGRs are "hundreds of meters deep, where surrounding media (rock, clay, or salt) offers a natural barrier to the escape of radioactivity…to the biosphere for at least several thousand years" (Feiveson et

al. 2011: 10). Following a brief cooling period in storage ponds, the plan is for HLW to be transported for final disposal in a DGR.

The nuclear industry remains confident that there are no serious technical barriers to achieving this objective and ultimately addressing what has long been identified as a major barrier to the continued use of nuclear power, however, finding social acceptance for DGRs has historically been quite challenging (NEA 2008b; Di Nucci et al. 2015).[67] At this time, there are no examples of operational DGRs for commercial spent fuel anywhere in the world. While Finland, Sweden, and France are close, none of these proposed facilities are expected to be operational prior to sometime in the next decade.

In all three countries explored in this study, plans for a DGR have been advanced with varying degrees of hostility and social acceptance. The risk literature has highlighted Sweden and Finland as cases where the acceptance of a DGR has positively influenced the public's view of nuclear power (Darst and Dawson 2010). Robert Darst and Jane Dawson (2010: 75) assert that "while securing public acceptance for a repository is neither a necessary nor a sufficient condition for the expansion of nuclear power, it is sufficiently important to tip the scales in a close contest." This hypothesis along with an exploration of public hearings, forums, and political processes concerning waste management will allow this study to explore one of the more democratic elements of nuclear policy development. When the public is allowed to directly participate in the

[67] There are some concerns over the safety of DGRs over the long term. There are also concerns that not all countries will have a geologically suitable site for a DGR. Each of the three case studies will discuss in some detail the challenges their respective HLW DGRs have faced.

creation of energy policy, it opens the door to testing the effectiveness of risk communication from the various stakeholders involved in this process.

Finding a solution to the nuclear waste problem has been presented by some as key to securing broader public acceptance for the future operation of NPPs and the potential construction and siting of new builds (ibid.). Using waste management as an intervening variable for assessing public acceptance of nuclear power is too simplistic a model to make a causal link, but it is worth seeing whether there is any correlation between these two variables.

Conclusion: A Nascent Dialogue Between Disciplines

As we have seen, no one body of literature encompasses the complexity of the problem when trying to explain divergent outcomes in the area of nuclear policy development. This study is an effort to bring together seemingly disparate literatures to highlight the theoretical blind spots created by disciplinary rigidity. Drawing principally from security studies, economics, and risk literature, this research presents a more complete picture of the options countries are faced with when determining the future of nuclear power in their respective political and social contexts. This study aims to refocus the discussion within the field of political science back to the relevant questions that help to shape energy policy today and away from its traditional focus on non-proliferation. The nuclear power literature succeeds in flagging a number of factors that might facilitate the expansion of a nuclear fleet (e.g. strong government support, reduced plant construction costs, limited public engagement, etc.), however, they tend to miss the contextual elements needed to explain observed policy outcomes.

A country's unique experience with the technology and the perceived alternatives at their disposal will serve to shape their respective nuclear trajectory. When it comes to energy policy it is argued that "decisions about future energy supply cannot be easily divorced from the interests, values and perceptions of the people and communities which energy systems are ultimately meant to benefit and serve" (Corner et al. 2011: 4831). These discursive landscapes will be explored in greater detail throughout this dissertation to help to better explain how national conversations have been formed over time and have served to delineate the contours of what is possible within their respective policy frameworks. This research seeks to shed light on how these policy choices are made and help to explain some of the factors that lead to disparate outcomes among similarly situated democratic states.

Chapter 3: Methodology and Approach

This chapter sets out to operationalize a new approach for how we look at commercial nuclear power development. Rather than thinking of the future of nuclear power in terms of binaries like drivers/constraints, or haves/have-nots, it is important to outline a more complete list of possible outcomes using an inductive approach. States often come to nuclear power from very different starting positions. These include differing levels of experience with the technology and economic development, not to mention political, regulatory, and social structures that are unique to each country.

This chapter will begin by introducing a typology that helps to organize the possible trajectories for commercial nuclear power followed by a detailed outline of the inductive method used to inform the methodology employed by this dissertation.

Commercial Nuclear Power Development: A Typology of Potential Outcomes

It requires considerable political, financial, and social commitment to advance a new reactor, a refurbishment project, or a complete phase out. Given the long lead times involved in the planning, licensing, and construction of a reactor, it is perhaps not all that surprising that there are multiple policy junctures where a nuclear trajectory might be obstructed, altered, or entirely reversed.

When looking at the current trajectory of a state in possession of one or more commercial NPPs, the question is no longer one of technology diffusion. Instead the emphasis is on the continued financial, political, and social commitment to the technology. Broadly speaking, there are three possible outcomes for states that currently operate nuclear reactors; they may opt to:

1) **Expand** existing capacity, with additional reactors on order, under construction, and/or plans for new capacity in the near term. These plans may include the refurbishment of existing capacity in conjunction with the acquisition of new capacity.
2) **Maintain** existing capacity with no plans for new reactors in the near term. This can include the refurbishment of existing capacity or simply the continued operation of existing NPPs. The important difference is that no new reactors have been ordered or are planned.
3) **Phase out** existing capacity, with no plans to build new capacity, or extend the life of their NPPs. A phase out may also include a planned date or timeline for the retirement of a country's entire fleet of reactors.[68]

For states that do not presently operate a commercial nuclear reactor, their options are distinct given their starting position. There are five possibilities:

1) **Adopt** nuclear power by ordering and ultimately building a commercial NPP.
2) **Reboot** a program. A state that operated an NPP in the past that has since been shut down decides to order and build a new reactor. In rare instances states decide to resurrect their program with a new build (e.g. Lithuania).
3) **Postpone** plans for their first NPP. In these cases, a reactor order may have been cancelled or deferred, for a variety of reasons including but not limited to issues

[68] It is worth noting that if a country currently operating NPPs postpones making a decision about the future of their program, they may by default fall into the maintain category. If they defer this decision too long, indecision could lead to a phase out. Peter Bradford (2013) notes that a similar level of government intervention is required to both maintain as well as a phase out nuclear power. He notes that without a serious course correction in the US, they are likely to shut down their last reactor only a couple decades after Germany, a country actively seeking to phase out the technology.

such as finding sufficient financing, problems with the supplier/vendor, site selection, reaction to an external shock like a nuclear accident, change of government, and/or lack of public support for the project. This option does not preclude a government from revisiting its decision at a later date. In these instances, there remains a continued interest in the technology.

4) **Abandon/reject** the option of nuclear power. In these cases, plans for adding nuclear reactors have been cancelled altogether with no plans to revisit the decision. Alternatively, no order was ever considered but a legal prohibition exists barring the option.
5) **Uncertain** about their energy future, a state may be agnostic on the issue and have no immediate plans to pursue or abandon the option.

For the purposes of this study, the focus is on the three possible outcomes for a state already in possession of at least one NPP. This will allow us to bracket the question of technology diffusion to be able to focus on issues arising from a long-term commitment to the technology among experienced players. This approach will be elaborated on and justified in the methodology and case selection criteria below.

Methodology and Research Design

To address my research question, I will employ a small-n comparative case study approach focusing on three states: Canada (Ontario), Germany, and Finland. This allows for a thick within-case analysis, complimented by cross-case comparison among similarly situated northern democratic states, with considerable experience operating commercial

scale nuclear power plants (Bennett and Elman 2006; George and Bennett 2005).[69] Each case is illustrative of one of the three possible policy trajectories for a state already in possession of a NPP. The dependent variable in my study is whether a country already in possession of at least one NPP decides to: expand, maintain, or phase out commercial nuclear power during the nuclear renaissance (2000-2015).[70] By focusing on industrialized democratic states, within a contemporary frame of reference, with considerable experience operating NPPs, we are able to better isolate causal mechanisms that drive energy policy today. The typology is meant to provide us a starting point for theory development, however the explanations for these outcomes will be derived from within-case analysis. We know from the outset what variance to expect on the dependent variable for each of the three cases, but we lack a strong understanding of "the detailed processes through which the outcome arose" (George and Bennett 2005: 112). Rather than apply rigid *a priori* assumptions about how these trajectories emerge, this study employs an inductive method, to identify the broad factors to be explored and tested within each case. They serve as points of entry, with the aim of identifying the more salient features of the decision-making process. This analysis will also highlight the

[69] All three cases included in this study have over 30 years' experience operating a commercial scale NPP.

[70] The nuclear renaissance is said to have begun at turn of the century however there is some disagreement over precisely when the era began (Findlay 2012; Nuttall and Taylor 2008; WNA 2015). Findlay (2012) notes the term had appeared as early as 1985, however most analysts agree that it did not begin until much later (between 1999 and 2001). In Findlay's study, he explored the likelihood of a major nuclear expansion by the year 2030. For our purposes, given the long lead-times associated with the construction of a new plant, a 15-year window gives us ample time to study and assess nuclear development in these case studies and the likely development in the near term. Where possible updates have been given through to summer 2017 (the period when this dissertation entered its final review).

limits of these broad characterizations and present other possibilities not initially anticipated by the researcher. Ultimately, this will allow the researcher to draw out stronger conclusions from a richer frame of reference and understanding of the dynamics that inform nuclear energy policy today.

In order to bracket the question of nuclear weapons and questions of non-proliferation, this study focuses on countries that have renounced the acquisition of nuclear weapons.[71] This dissertation is not exploring the factors that led to the initial development of their respective nuclear power programs, but rather the ongoing policy affirmation(s) needed for these programs to continue to operate and potentially grow during the period of study.[72] This research is attempting to create an analytical framework that can better explain the factors that help to sustain ongoing support for nuclear power development, the factors that stymie growth, and the factors that can lead to a wholesale rejection of the power source.

The nature of the national discourse on nuclear power has peculiarities that extend beyond the official discourse. Lene Hansen (2006) defines official discourse as direct and

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[71] It is worth noting that the early development of nuclear technology in Canada and West Germany had some linkages to weapons programs, however both countries renounced weapons early on (Paul 2000). In the case of Finland, there is no evidence to suggest that they ever pursued a weapons program (Levite 2002/2003). During the period of study, neither Canada nor Finland reprocessed or enriched fuel domestically. In the case of Germany, reprocessing at home and abroad has always been a contentious issue. They did use reprocessing technology in the past with the intention of establishing a plutonium economy that used fast reactors to close the fuel cycle. These plans were abandoned in the late 1980s. German operators continued to reprocess fuel abroad until 2005 as part of their waste management program. This issue will be discussed at length in the chapter on Germany.

[72] If you were to study states that did not currently possess the technology then the calculus would be somewhat different. For a nuclear newcomer, the factors that lead a state to adopt, reboot, postpone, abandon, or remain uncertain about a nuclear power program necessitate a focus on the formative years of the program.

secondary texts emanating from: heads of state, governments, senior civil servants, high ranking military officials, and heads of international institutions (or the institutions themselves). This study aims to cast a wider net that attempts to capture elements of the broader energy debate by drawing on interviews and primary documents from industry, nuclear-related fields of academia, and environmental opposition groups. No single event, policy, or constituency is solely responsible for the current energy trajectory of a given state. Instead, it is helpful to see how these policies have evolved over time, from various vantage points, to see the points of disjuncture, intervention, and reorientation. In no sense are the classifications set out in my typology of nuclear trajectories deterministic or fixed. They are meant to serve as a barometer or heuristic that helps the researcher to focus on how these trajectories took shape and to begin to better identify the causal conditions that led to their adoption.

Case Selection

This study explores most similar cases with differing outcomes. Finland, Germany, and Canada provide us with three northern democratic states that are experienced nuclear operators that have ultimately adopted very different policies towards nuclear power during the nuclear renaissance. Finland began construction on a new reactor at Olkiluoto in 2005, with plans for another reactor on the Hanhikivi peninsula in 2018. Canada by contrast has cancelled and/or deferred plans for new capacity at multiple sites during the period of study, opting to refurbish existing capacity in Ontario and New Brunswick.[73] The Canadian chapter focuses on the case of Ontario,

[73] Plans to refurbish capacity in Quebec were scrapped when a new government was elected in September 2012.

the province which is home to the vast majority of the country's nuclear reactors.[74] For its part, Germany is committed to a nuclear phase out, with plans to shut down all of its reactors by December 31, 2022. This study explores the factors that led similarly situated democratic countries to pursue different energy trajectories in the area of nuclear power. These countries are, broadly speaking, comparable in terms of governance, development, and experience with nuclear power, and yet national political discussions in conjunction with their experiences with the technology have played a deciding role in their nuclear futures. This study hopes to parse out the factors that led to these divergent policy outcomes.[75]

This study uses a case selection that borrows from James Jasper's (1990) book, *Nuclear Politics: Energy and the State in the United States, Sweden, and France*. Jasper noted that in 1973, the US, France, and Sweden had a robust commitment to commercial nuclear power. And while the 1973 energy crisis seemed to be the turning point that would ensure nuclear power's central role in producing electricity in these advanced democratic states through to the end of the century, and beyond, they ultimately took very different paths. "The three nuclear commitments could hardly have diverged more: the triumph of one reactor program [France], the collapse of a second [the United States], and

[74] Decisions related to electricity supply in Canada (i.e. the decision to build, refurbish, or close a reactor) rest with the province. As a result, much of the analysis in the Canadian chapter focuses on the decision-making processes taking place at the provincial-level, with a focus on Ontario.

[75] Other cases could have been added to this study, however, additional cases would present a challenge for doing good thick description and would reduce the degree of comparability in terms of governance, development and experience with nuclear power. This is a first cut at fleshing out an analytical approach that includes a representative set of cases. As a result, it need not be exhaustive. Future work will be able to apply this approach to a broader range of cases as appropriate.

the control and curtailment of a third [Sweden]" (Jasper 1990: 4). While France maintained its strong commitment to nuclear power and continued its rapid expansion, the US let the market run its course, leading to numerous cancellations and limited growth for the technology domestically. In the case of Sweden, political compromise limited its growth to 12 reactors. A 1980 referendum in Sweden called for a phase out by 2010.[76] Jasper's (1990) case selection reflected a similar objective, to try to discern why similarly situated democratic states with strong historical commitments to nuclear power ultimately adopted policies that led to distinct nuclear trajectories. For this study, I have selected states that represent similar trajectories for nuclear power but during a different period of study.

Period of Study: Why Look at the Nuclear Renaissance (2000-2015)

As discussed in the introduction, there are a number of defining characteristics that help to differentiate the current era of nuclear expansion from the past. Notably, weapons motivations are far less salient today for states considering new builds. This is evidenced by states willing to import their fuel rather than pursue domestic enrichment and reprocessing technology. It is also reflected in the slow growth of states acquiring nuclear weapons.[77] This poses a challenge for Sovacool and Valentine's (2012) claim that national security is a necessary driver for nuclear development during any period of study.

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[76] This policy was revisited in 1997. Sweden continues to operate nine NPPs, many of which have undergone significant refurbishment, however, no new reactors have been ordered (WNA 2017h).

[77] There are only nine states in possession of nuclear weapons, with North Korea being last country to join the club in 2006. It is worth noting that North Korea does not have a commercial NPP. For a contemporary discussion on why states pursue nuclear weapons see: (Sagan 2011).

Today, nuclear power is thought to be motivated, at least in part, by a concern over emissions. Following two decades of anemic growth, the nuclear industry has been trying to reinvent itself, to boost sales, and reestablish itself as key technology in electricity generation. As a result, the industry has been highlighting the pivotal role it can play in decarbonizing a country's electricity supply, in addition to promoting the technology as a cost-effective alternative to fossil fuels. Focusing on this period of study (2000-2015), allows the researcher to scrutinize the salience of this justification. How prominent was it and what role if any did it play in shifting public opinion and policymakers' support for nuclear power?

Perhaps most significant about this period of study was the long period of relative inactivity for the industry in the West. At this time, most Western democratic states had not ordered a new reactor in decades. The 1990s had been a period of perceived recovery for the industry buoyed by a return to profits in the US, a remarkable record of construction in Asia (principally China, Japan, and South Korea), and signs that public opinion towards nuclear power was beginning to improve in many countries (Nuttall and Taylor 2008). There were great expectations that this might prove to be a decisive moment in the industry's history. However nuclear power would have to prove its merits in the context of competitive liberalized electricity markets with limited government support and genuine public consultation. Germany, Finland, and Canada provide a window into how the technology might fare within democratic states with a long history of operating NPPs, and a strong international commitment to carbon reductions.

Data Collection

This study relied on the use of interviews with key stakeholders involved in the nuclear discussion within their respective countries. This included 48 one-on-one semi-structured interviews conducted by the researcher over the phone, Skype, or e-mail with participants in Germany, Canada, and Finland. In a handful of cases, in-person interviews were conducted at a mutually agreed upon location.[78] These interviews were conducted between August 27, 2014 and July 7, 2015. They included individuals involved in the nuclear industry (and related associations), government officials (including elected officials and bureaucrats), members of the nuclear regulator(s), members from public interest groups (namely environmental groups), and academics from nuclear-related fields. Interviews were meant to last 35 to 50 minutes but in practice ran between 30 and 60 minutes depending on the length of responses given by participants and their availability for additional questions.[79]

[78] Only 3 out of 48 interviews were conducted in-person.
[79] Originally the consent form indicated that interviews would last 20 to 35 minutes but I quickly learned that this would not provide enough time to complete the interview. I subsequently revised this component of the consent form to better reflect the amount of time needed to complete the interview. In some cases, interviews ran well beyond an hour but this was not typical.

Table 1: General Breakdown of Participants in Study[80]

Country	Total Number of Participants	Government/ Bureaucrats from Appropriate Ministry	Regulator/ Advisory Body	Environmental Interest Groups	Academia & Think Tanks (Nuclear-Related Disciplines)	Industry & Related Associations
Canada	28	2	4	2	4	16
Germany	11	1	3	1	2	4
Finland	9	2	1	2	1	3
Total:	48	5	8	5	7	23

Prior to beginning the study, I had no contacts or affiliation with the nuclear industry, environmental groups, or political actors involved in the development of nuclear policy. In order to find the contacts necessary for this study I attended three industry conferences (see table 2 below).

[80] Some participants would fit into multiple categories. For example, academics often had past experience in the nuclear industry or had ongoing research or consulting work paid for by industry. Academics could in some cases also be members of nuclear associations that are closely tied to the industry. For our purposes, the table is simply meant to be illustrative of the broad constituencies consulted for this study. In the case of Germany, there were interviews with members of advisory bodies that serve as part of the decentralized regulatory apparatus. These individuals also worked as researchers at universities and think tanks. A more detailed description of these advisory bodies can be found within the chapter on Germany. See Appendix 1 for a complete list of those interviewed for this dissertation.

Table 2: Industry Conferences Attended

Name of Conference	Organizer	Date and Location
The 19th Pacific Basin Nuclear Conference (PBNC): Fulfilling the Promise of Nuclear Technology Around the Pacific Basin in the 21st Century	PBNC[81]	24-28 August 2014, Hyatt Regency Vancouver, BC
The 2015 Canadian Nuclear Association (CNA) Conference and Trade Show: Power for a Cooler Climate	CNA	25-27 February 2015, Westin Hotel, Ottawa ON
The 2016 CNA Conference and Trade Show: The Core of Canada's Low-Carbon Future	CNA	24-26 February 2016, Westin Hotel, Ottawa ON

At these conferences, I was able to make contacts with members of the nuclear industry, academia, government officials, industry lobby groups, and members of the Canadian nuclear regulator. Other contacts were made by contacting specific stakeholders directly or through corporate communications departments. In the case of environmental interest groups, I contacted a variety of associations directly through e-mail and social media and was put in touch with some additional participants through the snowball technique.

Interviews with industry insiders were meant to provide insight into their experience working with the public, the regulator, civil society, and the government. Industry in this case was defined broadly to include: engineering firms involved in

[81] The conference was co-hosted by Natural Resources Canada (NRCan), the Canadian Nuclear Society (CNS), and the CNA, in partnership with the IAEA.

nuclear refurbishment and construction, utility companies,[82] national nuclear societies,[83] and in the case of Canada, Canadian Nuclear Laboratories (CNL).[84] These interviews were meant to explore the industry's views on nuclear opposition groups, public consultation over new projects, and the broad contours of their communication strategy with policymakers and the public. Participants included among others: CEOs, communication directors, and consultants to the industry.

Interviews with elected members of government meant to give insights into the nuclear policymaking process proved difficult to secure. Only two elected officials currently sitting in parliament agreed to participate; both happened to be members of the Green League in Finland.[85] The former Ontario Minister of Energy and Infrastructure also agreed to be interviewed for this dissertation. Bureaucrats interviewed for this study came from the ministries responsible for nuclear power in Finland, Germany, and Canada. These interviews tended to direct the researcher to policy documents, recent policy announcements, general concerns regarding the industry, along with some insights into government communication with the public.

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[82] None of the big four German utility companies (RWE, EnBW, E.ON and Vattenfall) were willing to provide an interview on the record; however, I was able to secure anonymous interviews with industry insiders in Germany. This was not an issue in Canada or Finland.

[83] Nuclear societies tend to have commitments to academia as well as industry. Given their ties to industry, it seemed difficult to list them as academic research groups even though many of their aims are similar. They serve multiple functions related to the advancement of the technology and related fields. See for example: (CNS 2015).

[84] CNL is what is left of a much larger crown corporation formerly part of Atomic Energy of Canada Limited (AECL). Its history and restructuring will be discussed in greater detail in the chapter on Canada.

[85] Elected officials who responded to my interview request often stated that they did not feel comfortable speaking about the issue, did not feel sufficiently knowledgeable about the technology, or felt another ministry/department could better handle my query.

Regulators and members of regulatory advisory boards provided a more technical account of the state of the industry and their engagement strategy with the public. The regulator is meant to be at arm's length from the industry and the government and is apolitical in orientation. These interviews tended to look at licensing issues for specific projects, concerns over an aging workforce, the ability to assess new designs, and, overall, tended to provide a very different perspective on consultation and social licence when compared with industry.

Environmental groups provided diverse insights into questions of public acceptance and communication, and served as an ideological counterweight to the technological optimism found in many of the other interviews, given the generally entrenched anti-nuclear stances they held.

Academics and members of think tanks provided diverse opinions that escaped easy classification. Those more closely aligned with industry tended to be able to provide less constrained accounts of the state of affairs for the industry, particularly in terms of challenges for research and development (R&D). Academics and researchers who worked at a distance from industry or actively opposed nuclear power, provided stark and often refreshing critiques of the industry. Not unlike some environmental groups, their distance from industry allowed them in some cases to provide a more impartial assessment of the issues they saw facing the nuclear industry, particularly in terms of communication.

Taken together, these groups can be broadly thought of as five of the principal stakeholder groups involved in the process of nuclear policy development. These

interviews allowed me to fill in some of the blanks left by the secondary literature, press releases, and policy documents available in the public domain.

Exploring three Divergent Energy Trajectories: What to Expect

Earlier in this chapter, I laid out the possible energy trajectories available to states with existing nuclear capacity versus those considering initiating a new program. To allow a more structured comparison, the cases selected (Canada, Germany, and Finland) limited the focus of this study to democratic states with a long history of operating commercial NPPs. Each state represents one of the identified nuclear trajectories: expand, maintain, and phase out. The case selection provides us with broadly comparable states that, during the same period, emerge with divergent policy outcomes. Based on the literature review, there are many variables that are widely thought to influence policy decisions surrounding nuclear power (e.g. government support for industry, economics, public support, etc.). What is not known is how these factors interact with one another to shape these unique policy trajectories. No single factor or decision leads to a particular nuclear trajectory. Instead, it is likely that a confluence of factors combine in different ways to create the observed policy outcomes. A thick within-case analysis will allow the researcher to test these broad factors in order to assess their salience and relative importance to the decision-making process. This will clarify the "conditions under which specified outcomes occur, and the mechanisms through which they occur" (George and Bennett 2005: 31).

Based on the literature review undertaken in chapter two, below are some of the hypotheses the researcher sought to test regarding the determinants that shape nuclear trajectories.

States Opting to Expand their Nuclear Fleet

From the outset, it is not clear that all of these variables are necessary or sufficient to explain why a state opts to continue building new nuclear capacity. Instead they can be viewed as potential explanations that help to partially clarify how countries like Finland are able to continue to build and operate nuclear reactors, while other states interested in doing so do not achieve the same results.

It would be expected that in these cases: (1) the government would be supportive of the nuclear industry as well as nuclear R&D; (2) the regulator would work cooperatively with industry to help deliver projects in a timely manner; (3) effective communication from industry and/or government officials would be used to connect with the public and policymakers to convince them of the benefits of the technology (i.e. presenting nuclear power as a low-emissions and cost-effective source of electricity); (4) opposition groups would have limited access to policymakers or be ineffective in their messaging; (5) the public would be supportive of nuclear power, disengaged from energy policymaking, or not included in the process in a substantive fashion; (6) economic and technical barriers would be accounted for and well-managed; (7) a waste management plan would be in place and positively correlated with nuclear expansion; and (8) the supplier of the NPP(s) and related-financing plans would be acceptable to the public and policymakers.

States Opting to Maintain their Existing Capacity

Given that refurbishment is expected to extend the life of a reactor by up to 30 years, states opting to maintain their capacity are likely providing some degree of support for the industry and the technology. Their initial preference may have been to expand

capacity, but for a variety of reasons the maintain option proved more feasible. There may not be sufficient demand to justify ordering new capacity. Alternatively, nuclear power might enjoy some political support, but not the requisite public support needed for new builds. These decisions could also be driven by the high costs associated with new construction. Finally, it could be the case that support from the government for expansion may be inconsistent over time leading proposed nuclear plants to get cancelled (Jasper 1990).

In these cases it would be expected that: (1) government support for the nuclear industry and nuclear-related research would be limited or inconsistent over time; (2) onerous regulatory requirements might serve to dissuade utilities from pursuing new construction; (3) industry communication with the public and policymakers would have experienced only limited success conveying the benefits of nuclear power (i.e. nuclear power's role in combatting emissions would be contested or not clearly endorsed by the public); (4) environmental groups and those opposed to nuclear power would have had some success stymieing new projects; (5) the public would be ambivalent about nuclear power, providing neither strong support nor strong opposition to the technology; (6) there would be issues associated with a new build related to its high capital costs; (7) a waste management plan would still be under development, hurting the prospects for nuclear expansion; and (8) in the case of Canada, the restructuring of AECL, a central player in the Canadian nuclear supply chain, would hinder the development of new projects.[86]

[86] The restructuring of a utility company or other key player in the industry would be expected to have a similar effect on the nuclear development of another country.

States Opting to Phase Out Commercial Nuclear Power

It would be expected that in these cases: (1) state support for the industry and nuclear-related research would be limited; (2) industry communication with the public and policymakers would be non-existent or ineffectual; (3) environmental groups would have successfully framed nuclear power as a problematic technology whose risks outweighed its benefits; (4) the public would actively oppose nuclear power and support the phase out; (5) waste management plans would have proven to be contentious and as a result remain unresolved; (6) nuclear power would not be viewed as a suitable technology for reducing emissions; and (7) plans for the phase out would not be seen as likely to lead to serious technical challenges (e.g. to lead to disruptions of supply) or be associated with insurmountable costs thought to make the process prohibitively expensive.

Given that a phase out is a political decision, the role of the regulator in these instances seems less relevant. Similarly, I would not assume that economic considerations regarding the relative costs associated with new builds versus refurbishments would play a significant role in the decision-making process. Given the costs (both political and economic) associated with barring an industry from operating its plants domestically, there would need to be strong support for this outcome coming from the electorate.

Conclusion

Given the limited number of cases, the findings from this study cannot be viewed as conclusive. Instead they provide us with a starting place from which we can discern the variables that are significant in determining a country's policies towards commercial nuclear power and separate them from those less salient. The depth of the three case

studies will allow the researcher to refine their approach, and to "reformulate [the] initial explanations of a case in ways that accommodate new evidence" in order to better account for how a particular nuclear trajectory took shape (George and Bennett 2005: 112).

This dissertation aims to develop a new analytical approach for assessing when a country decides to expand, maintain, or phase out commercial nuclear power. In the chapters that follow, these assumptions will be tested and evaluated against the experiences of Canada, Germany, and Finland during the nuclear renaissance. These states adopted nuclear power decades ago, but in recent years have allowed their programs to chart very different courses. These policy choices can gradually shift over time and are subject to change. This dissertation seeks to uncover some of the key drivers that served to shift the political landscape leading to the adoption of these divergent nuclear trajectories. It will conclude with the lessons learned across the three case studies, and what they tell us more generally about the future development of commercial nuclear power for non-nuclear weapons states already in possession of at least one reactor. This study will expand on the key themes emerging from the three cases and seek to explore how particular combinations of factors serve to advance the development of commercial nuclear power in one case and yet work against it in others. This will clarify how future cases could be assessed while serving to expand and refine the typology moving forward.

Chapter 4: Expanding Capacity in Finland

Finland provides us with an interesting case of a state that has considered multiple proposals for reactors since 2000 and appears likely to complete two projects by 2024 (WNA 2017g). As one of the first countries to build a reactor during the so-called nuclear renaissance, we will get to test many of the industry claims made regarding the next generation of reactors: in particular, claims related to lower construction costs and faster build times.

This chapter will explore the challenges of getting initial government approval for a new reactor, and those that follow as it goes from early planning stages, to construction, commissioning, and eventual connection to the grid. Even when construction begins on a reactor, this does not signal a guarantee that it will ever come into service. The Finnish case aims to highlight the many opportunities that exist to delay, defer, and even cancel projects throughout the course of their development.

This chapter will begin with a brief introduction to Finland's existing nuclear program, including its history, the key stakeholders involved, and the legislative process for approving a new reactor. It will then discuss in greater detail what led to the successful decisions-in-principle (DiP) for three new NPPs and a DGR since 2000. This will be followed by a discussion of the challenges the proponents of the Hanhikivi NPP and Olkiluoto 3 (OL3) have faced since that time. This chapter will conclude with a brief discussion of the limited engagement of the public in Finnish energy policy and the marginalization of opposition groups within the national debate on nuclear power.

The Finnish Nuclear Experience

Finland, like so many other states took an interest in nuclear power during the Atoms for Peace era, initiating early studies into nuclear power in 1955. At that time, key stakeholders included the Finnish Atomic Energy Commission (AEK), the Ministry of Trade and Industry (MTI), the utilities, and the Finnish Government (Hellström et al. 2013). By 1962, with a research reactor already up and running, there was a growing interest in being the first to launch a commercial scale plant. At the time, both the state-owned Imatran Voima (IVO) and the private consortium Pohjolan Voima (PVO) were studying the possibility of building an NPP. In 1966, a special committee recommended to the government that IVO was the most capable and therefore should be the first to build a reactor, followed by the private utilities (Hellström et al. 2013; Vehmas 2009).

IVO, for its part, had by 1965 already begun to solicit tenders for an NPP from Canadian, German, American, and Swedish engineering firms. IVO was seeking a turnkey 300-MWe plant with a proven design. While it favored Western designs, in particular a West-German design, Cold War considerations forced IVO to consider a Soviet design (Hakkarainen and Fjaestad 2012). Moscow had lobbied the Finnish Government directly to consider a 400-MWe reactor, but there were serious issues with their proposal. After abandoning the open bidding process in 1967 that had included Western vendors, Finland briefly considered building its own reactor before agreeing to build a Soviet-designed plant in 1969.

By December 1969 IVO had formally signed a deal for the delivery of its first unit at Loviisa with a Soviet engineering firm, Technopromexport. Initially IVO, and Finnish authorities had been concerned about the Soviet approach to nuclear safety and

the lack of a completed reference plant. This led to a partnership with a handful of Western companies, including Westinghouse and Siemens. Their assistance was seen as critical to ensuring that the Loviisa plant met Western safety standards (Hellström et al. 2013).[87] The Loviisa plant incorporated Western instrumentation and control (I&C) systems, as well as improved containment structures (WNA 2017g). Unit 1 was completed in 1977, with unit 2 coming online in 1980. As a result of uprates and lifetime extensions granted in 2007, they have extended their operating lives from 30 to 50 years. Loviisa 1 and 2 are now expected to operate until 2027 and 2030 respectively.

In 1998, the state-owned utility IVO merged with the state-owned oil company, Neste Oy, to became Fortum Power and Heat Oy (now simply known as the Fortum Corporation or Fortum). Fortum has since sold its oil assets but remains a key player in Finland as a major utility company. In terms of its nuclear assets, in addition to Loviisa 1 and 2, it also owns a 26.6 percent ownership stake in Teollisuuden Voima Oy's (TVO) which owns and operates Olkiluoto 1 and 2. Fortum has also purchased a 25 percent stake in the Olkiluoto 3 unit under construction, a subject we will return to shortly.[88] Fortum has been publically traded on the Helsinki Stock Exchange (Nasdaq Helsinki) since 1998, however 51 percent of its shares remain state-owned (IAEA 2013).

TVO is the only other utility company that owns and operates nuclear reactors in Finland. Formed in 1969, it was created in response to the pulp and paper industry's

[87] These modified 488 MWe VVER-440/V-213 reactors were nicknamed "Project Eastinghouse" as a result of the collaboration (Hakkarainen and Fjaestad 2012).
[88] Fortum also owns nuclear assets in Sweden which include 22 percent of the Forsmark NPP and 43 percent of the Oskarhamn NPP.

desire to get their own reactor. TVO was created on the basis of the *Mankala Principle*.[89] This investment structure emerged in Finland and Sweden during the 1930s as a means of financing costly hydro power plants. It was a practice common to the forestry industry, which sought to acquire their own means of electricity generation (Vehmas 2009). Instead of selling the electricity their plants produce directly to the market and sharing the overall profits, it is meant to provide electricity directly to the investors themselves. The consortium is created to build and operate these large power plants, which in turn helps to ensure access to a stable low cost supply of electricity for the ownership group. Mankala investors receive a share of the electricity produced relative to their initial investment in the plant at the cost of production. When it was founded, TVO was comprised of 16 companies that accounted for 40 percent of Finland's energy consumption (Hakkarainen and Fjaestad 2012: 238).

In the case of TVO, the ownership structure includes an assortment of Finland's largest industries, small- and medium-sized utilities along with some state-ownership.[90] It has proven to be an important means of risk-sharing when it comes to the high capital investment costs associated with nuclear power in a liberalized electricity market (WNA 2017g; Syri et al. 2013).[91] Unlike the state-owned Fortum, which has other conventional

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[89] The Mankala Principle refers to a 1963 case from the Finnish Supreme Administrative Court that set the legal precedent for these types of financing arrangements.

[90] Their largest shareholder is PVO, owns a 58 percent stake in TVO. PVO is another Mankala company that produces over 20 percent of Finland's electricity, and whose majority shareholders are the pulp and paper giants UPN Oyi and Stora Enso Oyi. Other significant TVO shareholders include EPV Energia Oy, Fortum, Karhu Voima Oy, Kemira Oyj, and Oy Mankala Ab. For a breakdown of TVO's ownership group see: (TVO n.d.).

[91] Investors are required to purchase their share of the electricity produced by the plant, even if it is higher than the market rate. They are also responsible for maintenance costs associated with the plant (Schröder and Pirttilä 2011).

generating capacity, TVO's main business is as a nuclear operator. TVO operates the two units at Olkiluoto, with plans for a third coming online in 2018.[92] Unit 1, an 840MWe BWR was ordered in 1972 from the Swedish engineering firm Asea-Atom (today part of Westinghouse) and completed in 1979. The second 880MWe BWR unit was ordered in 1974 and completed in 1982.

Table 3: Finland's Operating Nuclear Fleet (as of 27 June 2017)

Name	Utility	Supplier	Type/Output	Ordered	Com.[93]
Loviisa 1	Fortum	Technopromexport	VVER-440 496MWe	1970	1977
Loviisa 2	Fortum	Technopromexport	VVER-440 496MWe	1971	1981
Olkiluoto 1	TVO	Asea Atom	BWR 880MWe	1974	1979
Olkiluoto 2	TVO	Asea Atom	BWR 880MWe	1975	1982

TVO and Fortum have not only extended the lives of these reactors for decades, but have improved their performance and output as well. Olkiluoto Units 1 and 2 have improved their net rating from 660MWe when they were first commissioned to 880MWe, a more than 30 percent improvement (IAEA 2013; WNA 2017g). The Loviisa units have been uprated from their original 420MWe to 496MWe (IAEA 2013). In addition to these uprates, the Finnish nuclear fleet has achieved an impressive 85 percent load factor over its lifetime and 95 percent over the last ten years (WNA 2017g). In short, although Finland possesses a small nuclear fleet, Fortum and TVO have proven to be more than capable nuclear operators.

Today, these four reactors account for roughly 30 percent of Finland's electricity production. That being said, Finland remains dependent on large imports of electricity

[92] TVO also owns a 45 percent stake in Fortum's 565 MWe coal-fired power plant at Meri-Pori and a 1MWe wind power plant at Olkiluoto.
[93] Commercial operation began.

from Sweden and Russia. Finland has been a net importer of electricity since the 1990s, procuring on average 19 percent of its supply from imports (IEA 2013: 120). As of 2013, roughly 22 percent of electricity consumed domestically was from imported sources (CIA 2015). New nuclear capacity has been highlighted by Finnish operators as a key tool needed to remedy this high degree of energy insecurity.

Nord Pool and Finland: The Shared Electricity Market

Before entering into a discussion of Finland's plans for new nuclear capacity, a little background on its electricity market is needed. In the past, the state-owned vertically-integrated utilities owned both the transmission networks as well as the power plants. Being state-owned, their objective was to deliver low-cost electricity to its end-users rather than worrying about short-term profits. This gave them the freedom to make long-term investments in infrastructure that might be beneficial over the long-term but not necessarily profitable right away. Liberalized electricity markets by contrast have tended to be an effort to break up these state monopolies. Liberal markets tend to separate generators from grid operators, and the wholesale utility companies from the retail utilities. Broadly speaking, the process of liberalizing electricity markets has meant a shift away from large government-owned vertically-integrated utilities to increased privatization and distribution of these assets to smaller utilities.

Interconnections between Norway, Sweden, Finland, and Denmark date back to the 1960s, but they have not always traded electricity on equal terms. Norway and Sweden started Nord Pool in 1996 as a shared electricity market. Finland joined in 1998, giving it time to make the necessary changes to liberalize its internal electricity market. While reforms have led to a division between generation and transmission capacity, it has

not forced public utilities to privatize their assets. It is also worth noting that state-owned grid operators continue to play an integral role in managing the power exchange (Carlsson 1999).

Nord Pool is said to make better use of the generating capacity between the four member countries and ultimately serves to reduce electricity prices for end users by creating a shared market with equal access for participating utilities that own generation capacity and those purchasing the power at the retail or wholesale level (Nord Pool 2004). The pool allows smaller players, like regional utilities on the retail side, to gain better access to the national grid at competitive prices that had been previously denied to them under the old system, which was dominated by large public utilities. Nord Pool also plays an important role in providing information to all of its participants as well as the public about transmission capacity, consumption rates, supply, surpluses, and scheduled maintenance at power plants to avoid unnecessary market volatility (Nord Pool 2004). The transmission system operators (TSOs) in Sweden, Norway, Finland, Denmark, Estonia, Lithuania, and Latvia own and operate Nord Pool.[94]

In the case of Finland, the public utility IVO was partially privatized when it became Fortum in 1998. In addition to the partial privatization of IVO, a national grid was created in 1997 by merging the state-owned IVS and the industry-owned TVS into Fingrid, a unified TSO. Until 2011, Fortum and PVO had a combined 50 percent stake in Fingrid which they have since sold in order to comply with the EU Internal Market

[94] Nord Pool has a spot market that helps to set the price for the day-ahead market by-the-hour; it also provides intraday trading, and a futures market for those interested in a means of hedging electricity prices. It operates in 9 countries including a subsidiary market in the UK. A high-voltage direct cable connection between Denmark and Germany has extended Nord Pool's market to include Germany.

Directive in Electricity (MEE 2011). The directive called for the separate ownership and management of generation and transmission capacity within the EU by March 2012. Today, Fingrid's majority shares are held by the Finnish State, with the remaining shares owned by a handful of insurance companies in Finland (Fingrid n.d.).

The state continues to play a meaningful role in the electricity market in Finland through its remaining ownership stake in the generation and transmission infrastructure within the country. While the state has been pressured to deregulate elements of its electricity sector to improve access to the grid, neither Nord Pool nor EU requirements have forced the state to extract itself entirely from the electricity market.

Liberalized Electricity Markets and the Mankala Principle

Within the context of a liberalized electricity market, the economic attractiveness of existing nuclear capacity versus new builds has become far more pronounced. High construction and financing costs associated with a new NPP can make them particularly unattractive to investors.

Roughly 70 percent of the lifetime costs associated with a typical NPP will come its construction and financing (Linares and Conchado 2013).[95] Given the rising costs of new builds outlined in Chapter 2, and the difficulties associated with forecasting the final construction costs of Generation III/III+ designs, it is not all that surprising that companies seeking to build new NPPs have struggled to find private investors willing to

[95] Of course, these are estimates that conspicuously fail to elaborate on decommissioning costs and assume that plants will operate for their planned lifetime with ambitious lifetime load factors. In practice, the operator is responsible for those costs regardless of plant performance (Thomas 2010). The WNA (2015) suggests that decommissioning costs amount to roughly 9 to 15 percent of the initial capital costs associated with a NPP.

take on the financial risks associated with such a project. Public utilities had historically been able to absorb these costs through rates hikes passed onto the end-user.

Liberalized markets by contrast do not incentivize long-term investments in capital intensive infrastructure like an NPP, where their ability to turn a profit is far from guaranteed. In an environment where spot prices determine what the market will bear, there is no assurance that a plant will ever be profitable, let alone break even (Kee 2015).[96] As a result, governments have often been forced to create programs that provide subsidies to utilities in order to incentivize the new construction of NPPs.[97] For example, the UK Government has agreed to pay a guaranteed strike price for electricity produced by Hinkley Point C for the first 35 years of its production in order to reduce risk to investors involved in the construction of the new £18 billion NPP (Ward 2016). This program is expected to cost taxpayers up to £29.7 billion (ibid).[98]

In the case of Finland, the Mankala Principle is thought to be an alternative means of distributing the risks associated with new construction. It does so in three important ways: it distributes the risk of investment among multiple owners within the consortium; it guarantees the sale of electricity from the plant over its lifetime at the cost of production (regardless of how high that cost might ultimately be); and it offers tax-free

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[96] Less capital-intensive projects like natural gas plants continue to be more attractive investments in liberalized electricity markets. In the case of a Combined Cycle Gas Turbine (CCGT) plant, roughly two thirds of its lifetime costs will be derived from fuel, keeping construction costs quite low by comparison (Nuttall and Taylor 2008).

[97] See chapter 1 for a discussion of the incentives provided in the US to incentivize new builds. In the context of the US, these incentives have

[98] The UK Government has agreed to pay a strike price of £92.50/MWh (plus inflation) for 35 years. By contrast, the average 2016 wholesale electricity price in the UK was only £45/MWh, less than half of the expected strike price (Ward 2016). These measures were seen as necessary given that no nuclear plant had been ordered or built since the UK integrated its nuclear fleet into its liberalized electricity market in 1996 (Thomas 2010).

production to its owners. It also provides a secure source of electricity for industry that is not subject to spot price volatility found on the Nord Pool Exchange. The Mankala Principle provides certainty to its owners without requiring a substantial production subsidy as we have seen in the cases of the US and the UK, making it potentially an attractive model for others to replicate.

Key Stakeholders and the Decision-Making Process

Equipped with a basic understanding of the electricity market in Finland and its nuclear history, this section outlines the key players involved in the decision-making process for Finnish nuclear policy. This process involves a variety of players, with diverse interests that can serve to facilitate or frustrate a proposed project at multiple junctures along the way.

Government

Within the Finnish decision-making apparatus, the government plays a significant role through a number of government actors. Notably, when deciding to build a new reactor, the cabinet and parliament will ultimately make a political decision to approve or reject a new build in what is referred to as a Decision-in-Principle (DiP). The DiP involves consultation with the regulator (the Radiation and Nuclear Safety Authority or STUK) and the Ministry of the Employment and the Economy (MEE),[99] who are charged with receiving the environmental impact assessments (EIAs) that accompany any DiP application. The MEE provides an initial review of the application and then submits its recommendations to the cabinet.

[99] The MEE is formally known as the Ministry of Trade and Industry (MTI). Matti Vanhanen's second cabinet restructured the MTI in 2007, creating the MEE as of January 1, 2008. Insofar as nuclear matters are concerned, the MEE replaces the role of the MTI.

A DiP is first voted on within the cabinet and then brought before parliament. The DiP, according to Section 11 of the Finnish *Nuclear Energy Act 1987*, calls for the government to make a determination on whether an NPP "is in line with the overall good of society." Ultimately parliament has the final say on whether an application is approved or rejected at this early stage (MEE 2015). Parliament for its part must ensure that the municipal government has consented to have the NPP in their community, otherwise the site can be vetoed at the local level (MTI 1987: Chapter 4, Section 14).

Parliament is not bound by any technical advice given to it on the issue. As a result, many of those interviewed for this dissertation noted that political and economic factors tend to be the key considerations for a DiP. The *Nuclear Energy Act* (MTI 1987: Chapter 4, Section 14) calls on government to consider whether a reactor is necessary in order to meet the country's energy needs, the appropriateness of the site, and the potential for adverse environmental effects as a result of its construction and operation. The government is also supposed to assess the utility's plans for how to deal with waste produced by the proposed reactor(s).

The Regulator

STUK serves as a unified national regulator "responsible for the supervision of safe use of nuclear energy" (MTI 1987: Chapter 8, Section 55). The regulator is meant to "protect people, society, the environment and future generations from the adverse effects of radiation" (STUK 2015). STUK is also charged with preventing the misuse and proliferation of nuclear technology for the purpose of creating nuclear weapons. To that effect, STUK plays a critical role in helping to process construction and operating licences for nuclear facilities, issuing detailed nuclear regulatory guides and supervising

and enforcing those regulations and safety protocols. As is the case in many states that operate reactors, it is the regulator that ensures that licensees (nuclear operators/utility companies) fulfill the requirements of their licences. STUK also serves as a source of nuclear expertise for the government and the public.

In terms of its public communications role, STUK tries to provide general and accessible information to the public about its operations, regulatory guides, recent decisions, and crisis communication when necessary. What is striking about their website is their efforts to make nuclear safety and radiation accessible to the Finnish public, by covering topics of public interest such as: tanning beds, cell phones, environmental radiation levels, and food safety in addition to more traditional concerns such as power plants, mining, and waste management (STUK n.d.). This speaks to one of their core values: openness. STUK claims to strive for the highest level of transparency with all stakeholders, including the public.

Environmental Groups

As is the case in many other Western states, environmental groups have challenged nuclear power and its continued use. When speaking to the Finnish regulator, and industry, the same groups tended to come up: Greenpeace, Pro Hanhikivi, and the Finnish Nature Conservation Association.[100] These environmental groups play an active role in lobbying legislators, participating in public hearings, and delivering their message

[100] It is worth noting that some participants filled many roles. One of my interviewees was a Green Party MP, a municipal councilor in Northern Finland, as well as the Vice President of Pro Hanhikivi. As with academic participants who often do work for industry, connections between green political parties and environmental NGOs are perhaps not all that surprising.

to the public on nuclear power. In short, they are the most visible and vocal critics of nuclear power in Finland.

Academia

Academia plays a unique role in that it is not part of the decision-making process, but it is necessary for the training of future engineers and scientists needed by industry. Academia also plays a pivotal role when it comes to innovation within the field, for example, designing the next generation of reactors, solving problems in existing NPPs, and studying issues related to nuclear waste. Academia serves as a custodian of knowledge that allows the industry to operate and continue to innovate.

Industry

Industry in Finland plays a critical role in all things nuclear. It is the central stakeholder which must decide whether to initiate the DiP process, and raise the necessary capital for what can prove to be a fruitless endeavor (e.g. a rejected NPP proposal). To apply for a DiP, a utility company must make the case that there is a need for a new capacity as well as conduct a detailed EIA for the proposed site and design. This application will then be submitted to the MEE, which will advise the government on the merits of the proposed NPP.

In some countries, 'industry' would principally refer to two parties: the operator of the NPP (i.e. the utility) and those companies involved in the construction of the NPP (likely a consortium of engineering firms). In the case of Finland, given the use of the Mankala Principle, the distinction is less useful. As we will see in the case of Fennovoima, local industry and municipal utilities, as well as the plant supplier, all have an ownership stake in the proposed plant, making it increasingly challenging to make an

analytically-useful distinction between operator and supplier of an NPP in Finland. By contrast, in the case of OL3, the difference between Areva (the supplier of the plant) and TVO (the utility) is far more pronounced.

The Public

The local community at the site of the proposed NPP does have an opportunity to have its voice heard during the public hearings conducted as part of the DiP process. The local population may submit written objections to the MEE, as well as attend public hearings hosted in communities at and around the proposed site. Residents and their municipal governments can play an important role in whether a project is ultimately green-lit or not through these public processes.

Finnish legislation provides municipalities with the added protection of a veto over the siting of NPPs. In the *Nuclear Energy Act 1987* (MTI Chapter 4: Section 14), it clearly states that: "before making the decision-in-principle referred to in section 11, the Government shall ascertain that the municipality where the nuclear facility is planned to be located…is in favour of the facility […]." Overall, there is a very strong element of local politics and public consultation built into the process that serves to inform the DiP at the national level.

A Fifth Nuclear Power Plant: The Third Time is the Charm

In the context of nuclear power, a decision can be revisited, delayed, or reversed, and is rarely final. It is instructive to look at Finland's fifth NPP, Olkiluoto 3 (OL3), as a good example of a project that has been politically contested for decades, in part explaining the slow growth of the country's nuclear fleet. While the focus of our

discussion is on the most recent DiP (2002), it is illustrative to trace the development of these plans and the discourse that accompanied this NPP.

There were three different DiPs submitted since 1986 for a fifth NPP in Finland (Litmanen and Kojo 2011). The initial DiP application was made in March 1986. It was proposed by a joint venture between IVO and TVO called Perusvoima Oy. While the Finnish Government was in favour of the project at the time, the application was pulled by industry following the Chernobyl accident in April of that year. In 1992, Perusvoima resuscitated plans for a fifth NPP following the election of the Centre Party in 1991.

In February 1993 Cabinet voted in favour of the application, but it was ultimately rejected by Parliament by a vote of 107 to 90 (Litmanen and Kojo 2011). Finnish politicians were acutely aware of the public's concern over the Chernobyl accident and the optics surrounding new builds at that time. Satu Hassi (pers. comm.), a Green Member of Parliament (MP) and the former Minister of Environment and Development, suggests "maybe fear over nuclear power played a bigger role in the nineties than we understood at that time." Hassi recalled that during the 1990s the industry seemed more interested in demonstrating the financial and technical advantages of building nuclear reactors. Their discussions with parliamentarians did not emphasize the environmental benefits or raise concerns about public opinion in Finland (ibid.).

During this period, 1986 to 1993, the specter of Chernobyl continued to loom large. Parliamentarians' opposition to the proposed plant also stemmed from a belief that cheaper alternatives were available (i.e. natural gas), with a lingering concern over how nuclear waste would be dealt with (Lammi 2009). Within Cabinet there were disagreements over how to handle the DiP. The Minister of Industry and Trade, Ilkka

Suominen, was actively campaigning in favor of it, while Esko Aho, the Prime Minister at the time, opposed the project. Aho argued that the government had not had sufficient time to develop a clear policy on nuclear power. This division within the Cabinet led the Aho Government to call for a free vote[101] on the issue, which might help to partially explain the defeat of the DiP (Säynässalo 2009).

During this period, the anti-nuclear campaign had support from well-organized NGOs, as well as vocal parliamentarians like Matti Vanhanen of the Centre Party in conjunction with strong opposition from the Greens (Lammi 2009). From 1993 to 2002, key material and discursive factors changed, making the approval of OL3 less problematic almost a decade later.

During those intervening years, memories of Chernobyl had become less salient, and energy needs had continued to grow. Emissions had taken on a central role in the debate over a fifth NPP given Finland's decision to join the Kyoto Protocol. Lingering concerns over the waste generated by a new NPP had also been put to rest. In May 2001, the Finnish Parliament approved a DiP for the industry-owned Posiva (a joint consortium between Fortum and TVO) to build a deep geological repository (DGR) in Eurajoki. Keeping in mind that TVO had submitted its DiP application for OL3 in November 2000, the timing could not have been better. Although Posiva's DiP only allowed for excavations to begin and additional onsite testing, it would pave the road for a construction and operating licence to follow (Darst and Dawson 2010).[102] Posiva for all

[101] A free vote allows parliamentarians to vote their conscience.

[102] These applications are in essence the same as those undertaken for a proposed NPP. As a result, they take time to be considered and have multiple stages. Plans for a DGR have a long history in Finland and have had to be modified over time. TVO had been in the process of exploring this model since 1978, while Fortum was forced to consider it

intents and purposes had now achieved the needed political consent at the local and national level to proceed with their DGR.

For industry, this decision meant that waste could now be presented as an issue that had been resolved. TVO could now move their discussion past long-standing irritants like nuclear waste management and safety, and focus on the net positives that nuclear power could deliver. For industry, this "positive energy definition" referred to a plant that could provide Finland with large amounts of carbon-free electricity and enable it to meet its Kyoto targets as well as achieve an increased degree of energy independence (Hassi pers. comm.). In a northern country, reliant on energy-intensive exports like steel, pulp and paper, and with limited options for increased hydroelectricity, "nuclear power [seemed] to offer a shortcut to a low carbon society without causing too much societal concern" (Litmanen 2009: 26).

A Strong Nuclear Coalition

Finnish industry had a strong coalition of actors with vested interests in getting OL3 approved, which remained relatively consistent during the 1990s through to the 2002 DiP (Ruostetsaari 2010; Litmanen and Kojo 2011). TVO maintained strong connections to heavy industry as a result of the Mankala Principle. Its ties to industry ensured that it also had a strong relationship with government. The energy debate for these actors was tied to the success of Finland, a success defined by its ability to export energy-intensive products. In order to remain competitive, it was in their interest to continue to promote nuclear power as means of achieving low-cost domestic electricity

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following the 1994 amendment to the *Nuclear Energy Act 1987* banning the export of spent fuel (Darst and Dawson 2010). Posiva has since received a construction licence for its DGR (Reuters 2015). When complete it will be the first of its kind in the world.

production with a minimal carbon footprint. This group of power brokers included a close relationship between Fortum, TVO, Finnish political parties (the National Coalition Party and the Social Democratic Party), labor unions, business associations, and the MTI[103] (Litmanen and Kojo 2011). This longstanding consensus on nuclear power amongst Finland's policymaking elite made it easier for industry to promote their interests in a consistent and clear fashion over time (Ruostetsaari 2010).

As noted earlier, the *Nuclear Energy Act 1987* requires that a proposed NPP be in accordance "with the overall good of society." To that effect, TVO argued that OL3 would meet this requirement in three ways: it would help Finland meet its emissions targets under Kyoto; it would reduce Finland's dependence on energy imports; and it would benefit domestic industry by providing them with a long-term, low-cost source of electricity (Lampinen 2009). By this logic, OL3 would be beneficial for the environment, industry, and the country's overall energy security. In a northern country with a relatively heavy carbon footprint, all reasonable efforts to reduce emissions were being considered. Industry chose to frame OL3 as a technological fix to this problem; one that would not require Finns to make a compromise between economic growth or the environment (Berg 2009). From 2000 to 2002, this stable coalition of pro-nuclear supporters opted for a

[103] MTI was a traditional ally of the nuclear industry in Finland. Until 2007, MTI was the ministry responsible state-funded R&D through the Technical Research Centre of Finland (VTT), energy policy development, as well as substantial elements of the nuclear licensing process. MTI was also charged with managing Finnish state assets, which included Fortum. Critics of the MTI saw it as too influential within the decision-making process. MTI was a powerful actor able to dominate the national debate through its role in energy policy development, its management of state companies, and the expertise it offered Parliament regarding climate change and energy policy (Lampinen 2009).

more elaborate and targeted lobbying effort that effectively reframed nuclear power as a tool against climate change.

By contrast, the effective anti-nuclear coalition of politicians, green NGOs, and the public seemed fractured and disjointed in their opposition to OL3 when compared to the 1993 DiP. Advocates of OL3 always spoke of a "positive nuclear decision or the energy decision," that served to create a clear connection with Finland's energy future and the approval of the fifth NPP (Hassi pers. comm.). During the 2000 to 2002 period, green groups had become fixated on the details of the project and failed to create a concise and compelling rebuttal to the pro-nuclear position.[104]

It has been suggested that advocates for the Olkiluoto project benefitted from having had the public and politicians debate the issue for such a protracted period of time, leading to a broader dissemination of their position. They also benefitted from a period when the anti-nuclear coalition was in relative disarray. Greenpeace Finland had been forced to close its offices in Helsinki from 1997 to 1999 due to economic difficulties arising from a high turnover among environmental activists within their ranks (Lammi 2009; Litmanen and Kojo 2011). In 1999, when the office reopened, there were only a handful of employees on hand, with just one part-time employee dedicated to the energy

[104] In an interview with the author, Hassi lamented that they had not been able to create a stronger message or brand for the 'no' campaign. "I see our failure with the PR side of the story." According to Hassi, green activists were unable to create their own version of the German Energiewende. This made it difficult for them to effectively convey their message to the public. Since then, there has been more attention paid to messaging, which has helped to craft campaigns like "Energy Renovation 2015" to better describe the vision for a renewable alternative. For more on this campaign see: (Energiaremontti 2015). The German Energiewende refers to Germany's plan to rapidly decarbonize their energy system relying principally on renewables. It is a topic that will be returned to in the chapter on Germany.

campaign (Lammi 2009). One activist explained to me that "the emotional appeal of the anti-nuclear movement was shrinking …when the decision [to approve OL3] was made" (Anonymous pers. comm.).[105] The anti-nuclear coalition's lack of resources put them at a distinct disadvantage when competing with a well-organized and well-funded industry. And while environmental groups were not excluded from the consultation process, their views were not taken seriously (Ruostetsaari 2010). "For many parliamentarians, opponents of the new NPP unit remained a vague, unfocussed group with which they had no close interaction" (Berg 2009: 115). Annukka Berg (2009) found that during parliamentary hearings expert testimony in committees by environmentalists was perceived as being biased and as a result dismissed as unreliable.[106]

From 2000 to 2002, the anti-nuclear coalition was principally comprised of a handful of environmental NGOs and Greens MPs. Their messaging had shifted from one concerned with the dangers posed by nuclear accidents, weapons proliferation and waste to one that emphasized the economic benefits of adopting renewable energy sources (RES), juxtaposed with the poor economics associated with nuclear power (Litmanen and Kojo 2011). Given that the pro-nuclear lobby was emphasizing the environmental and economic benefits associated with OL3, both sides were debating the same issues but disagreeing over the facts. Put simply, those who supported OL3 claimed it would help Finland reach its Kyoto targets in a timely manner without putting its economic

[105] In 1999 when the office reopened, it was rebranded as Greenpeace Nordic. The Helsinki office has grown to closer to 20 employees since that time (Anonymous pers. comm.).
[106] Berg's (2009) study relied on interviews with parliamentarians from multiple parties active during the 2002 DiP.

development at risk. By contrast, those who opposed OL3 viewed nuclear power as far too costly and ultimately a poor strategy for meeting Finland's emissions targets.

The 'no' campaign had opted to deemphasize traditional concerns over safety, risk, and the moral/ethical objections to nuclear power in favour of one that focused on the benefits of supporting alternative energy sources, namely renewables. While this may have seemed like a good tactical move to effectively challenge industry and the MTI, it was viewed with suspicion by parliamentarians and the media, who did not believe that NGOs could speak credibly on issues like employment, the economics of electricity production, and reactor safety. "This effort leads NGOs into unfamiliar fields of discourse, such as economics, technology, and jobs, where the companies, labour unions, and researchers, had considerably more credibility" (Lampinen 2009: 84).

The media, for their part, gave airtime to these positions, but failed to take the arguments seriously. An anecdote from Satu Hassi's 2009 autobiography describes an exchange she had with television presenters following a broadcast along with Harri Lammi of Greenpeace that highlighted this divide. After the taping of the show, Hassi and Lammi complained to the interviewers that the media was simply parroting the claims from MTI and industry that nuclear power was the most cost-effective means of reducing emissions for Finland and would lead to substantive job creation. By contrast, their counterarguments were gaining little traction with Finnish media.[107] The interviewer

[107] NGOs had been countering the MTI's claims by highlighting reports that contradicted their rosy economic projections and suggesting that there were more cost-effective alternatives. Lampinen (2009) suggests that the MTI only looked at supply-mixes that compared a nuclear future with one that relied principally on natural gas. Their failure to explore a supply-mix based on renewables was seen as artificially constraining the options available to parliamentarians to shape Finland's energy policy.

responded to their criticism by asserting: "But you see, what the Government or the Ministry of Trade and Industry say is objective. But what you two say, Harri and Satu, is not objective" (quoted in Hassi 2009: 238). Given that Hassi was the Minister of the Environment at the time, it is noteworthy that journalists felt the MTI was more credible on the issue of nuclear power. This experience highlights the uphill battle that green NGOs were facing in parliamentary committees, where their expertise, and their concerns over the technology were not viewed as objective. Instead they were dismissed as emotional, or in some way less objective than those supporting the development of OL3.[108]

A Political Divide over Olkiluoto 3 and the Posiva DGR

At the time, Paavo Lipponen's[109] Government supported the reactor, however there were disputes within Cabinet over this issue. Lipponen himself, a Social Democrat, and his Minister of Trade and Industry, Sinikka Mönkäre supported OL3, but Hassi, the Environment Minister and a member of the Green League, did not.[110] The Greens had agreed to disagree with Social Democrats about a fifth NPP in order to cooperate on a broader agenda that included support for the ratification of the Kyoto Protocol.

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[108] For example, anti-nuclear campaigners were concerned that long construction times for a nuclear NPP would force utilities to rely on coal for a longer period of time than was estimated by the MTI. On the economic side of things, they argued that nuclear power was only marginally more cost-effective when compared with renewables because the government assumed costs for both technologies would remain stable over time, rather than acknowledging that renewables as a technology were still maturing and likely to see reduced costs over the next decade (Hassi 2009). The costs associated with load balancing and transmission upgrades to support OL3 were also ignored by MTI's figures (Lampinen 2009). Opponents of OL3 were frustrated by the rosy assumptions put forward by the MTI in support of the project, and the limited effort on their part to consider a renewable alternative.

[109] Lipponen served as Finland's Prime Minister from 1995 to 2003.

[110] The Greens were included in Lipponen's first and second cabinet from 1995 to 2002.

In the lead up to the OL3 decision, the Lipponen Government was also able to secure Green support for Finland's nuclear waste management plan. On May 18, 2001 Parliament voted decisively in favour of the DiP, 159-3 (Vira 2006). The Greens had felt compelled to accept the DiP for the Posiva DGR because the host community had volunteered to host the facility. The municipality of Eurajoki, home to the Olkiluoto NPP, had agreed to host a DGR for HLW produced by the Loviisa and Olkiluoto NPPs. The Greens saw this as a positive outcome as it ensured that a DGR would not be forced on a greenfield site that did not already host a nuclear facility. Greens had won seats in communities that were fighting the siting of a DGR near their homes, so it was viewed as a bittersweet political victory to find a willing host community (Darst and Dawson 2010). It was characterized as a fair outcome whereby the community responsible for producing most of the country's nuclear waste would also be responsible for hosting it over the long-term. Hassi for her part suggests that this was the best option available at the time, given that it would still allow for the issue to be revisited when future licences were reviewed for the site and that ultimately this process could lead to a more suitable solution than the status quo (Hassi pers. comm.; Hassi 2009: 110).[111] Industry and pro-nuclear politicians viewed the approval of Posiva's DiP as effectively removing one of the key barriers to supporting additional reactors in Finland (Darst and Dawson 2010; Lammi 2009). For the Greens, approving OL3 was another matter entirely.

[111] With hindsight, the former environment minister suggests that it may have been a political mistake to support the government on this issue, however it was the responsible decision nevertheless. Environmental NGOs had warned Hassi at the time that a positive decision on Posiva opened the door to revisiting a fifth NPP, but she was resolute in her decision, and did not regret it. "My personal view is that it is a more responsible approach to have some idea for the solution [on nuclear waste]" (Hassi pers. comm.).

The Greens, in conjunction with the civil society groups, rejected government and industry claims that OL3 was environmentally friendly — in particular, the claim that it would help Finland achieve its carbon reduction targets under Kyoto. They argued that given the long construction time required for OL3, its contribution to Kyoto would come too late, requiring the use of coal in the interim, while doing little to reduce Finnish energy imports (Lampinen 2009; Hassi 2009). OL3 would also likely stymie the growth of renewables in the country as the grid would remain highly centralized and oriented towards a model that relied on baseload generation.

Perhaps what is most interesting about the position that was being advanced by environmental groups at that time was that they did not fundamentally oppose the use of the existing NPPs or the technology itself. Instead, they focused their attacks on the arguments being presented by those in favour of OL3, namely the ability to effectively reduce emissions, increase energy security, and stimulate economic growth. Put simply, they rejected the notion that nuclear power could serve as a technological shortcut to a low carbon economy (Litmanen 2009). Environmental groups asserted that building a new reactor would take far too long and cost far too much to achieve those objectives.

The OL3 DiP was approved by the Finnish Parliament 107-92 on May 24, 2002. The key political hurdle to building the first NPP in Western Europe since 1986 had been overcome. From the industry's standpoint, Posiva and TVO's OL3 DiP were just the beginning. Finland would still need to do more to achieve its carbon reduction targets and reduce its dependence on electricity imports. With the debate over the fifth reactor settled, it was believed additional units could be justified using a similar premise (the

environment, energy security, and the economy). Finnish industry was readying itself for a new era of nuclear expansion.

2010 DiPs: A Second Round of Nuclear Expansion for Finland?

In 2010, three DiPs for NPPs were brought before Parliament.[112] Two applications came from existing nuclear players (Fortum and TVO) and one came from a newcomer, Fennovoima. Fortum, which had abandoned plans for a proposed NPP back in 1999 to support the OL3 DiP, was seeking a third unit at Loviisa. TVO, for its part, expected OL3 to come online shortly and was proposing a fourth unit at Olkiluoto (OL4).

Unlike Fortum and TVO, which were proposing additional units within existing nuclear communities (Loviisa and Olkiluoto), Fennovoima was exploring the possibility of building a reactor at a virgin site in Finland. Of the three applications, only TVO's and Fennovoima's projects were approved by Parliament. At the time of writing, only the Fennovoima project continues to advance towards the construction phase. This project will be the focus of the next section. Fennovoima is an interesting case given that it is not a typical Mankala Company. While Fennovoima has always maintained that Finnish industries will own a majority stake in the company, a foreign partner will own a substantial share of the project.

Fennovoima Oyi: A New Model for Expansion?

The company was founded in 2007 with the express purpose of building a new NPP in Finland. It was launched as a company based on the Mankala Principle, but

[112] These applications had been submitted prior to 2010, but were voted on by the government in that year. The TVO application for OL4 was submitted on April 25, 2008. The Fennovoima application was submitted on January 14, 2009. Fortum submitted the Loviisa 3 application on February 5, 2009.

unlike TVO, its ownership group would require a large share of foreign investment as well. Voimaosakeyhtiö SF, a Finnish holding company, had a 66 percent stake in Fennovoima. The plan was for Voimaosakeyhtiö SF to sell those shares based on the Mankala Principle to several smaller Finnish shareholders (Fennovoima 2009a). E.ON Nordic, a subsidiary of the German utility company, held the remainder of the shares in the project (34 percent). The ownership group according to the company's filings with the MTI in 2009 suggested that of their 63 Finnish shareholders, 55 percent were local energy companies, and the remaining 45 percent were supported by heavy industry and retail (Fennovoima 2009b).[113] The initial DiP application did not specify a site or technology for the Fennovoima NPP. Instead, it presented three possible sites within Finland as well as three possible reactor designs (Fennovoima 2009a).[114]

Fennovoima's justification for a new NPP in Finland, while not without its own merits, still echoed many of the elements of OL3: security of supply, helping Finland achieve its environmental objectives, and economic development, in addition to the employment opportunities associated with plant construction (Fennovoima 2009a). One added justification for this plant unique to Fennovoima was a claim that there was a need to diversify ownership within the Finnish electricity market to increase the amount of nuclear power reaching everyday consumers and the wholesale market. The Fennovoima

[113] According to the original January 2009 DiP, all shares in the company, including those held by E.ON Nordic were the same class of shares.

[114] The three sites included: Hanhikivi in Pyhäjoki, Gäddbergsö in Ruotsinpyhtää, and Karsikko in Simo. The three reactors being considered at the time were Areva's EPR, Areva's SWR 1000 (also known as the KERENA BWR), and the Toshiba ABWR. While they had not decided on a specific technology at the time, they did state that they were seeking 1500-2500MW of capacity. Depending on the design, this would require one to two units.

plant was meant to fill the needs of Finnish heavy industries (namely the steel industry)[115] as well some 900 000 customers through retail markets (Fennovoima 2009b). In addition to the 3500 to 4000 workers involved in the construction of the plant, Fennovoima's plans called for up to 400 permanent personnel after completion of the plant (Fennovoima 2009b). The DiP also highlighted the substantial revenue an NPP would generate for the potential host community from real estate and municipal taxes as an economic incentive to help facilitate local interest and acceptance of the plant.

Fennovoima and TVO's applications were approved by Cabinet on May 6, 2010, and ratified by Parliament on July 1, 2010. Loviisa 3 was rejected by Cabinet and as a result not brought before Parliament.[116] Fennovoima had until this point been successful in acquiring the needed economic and political support necessary to advance their project. However, things would become much more challenging following the success of their initial DiP.

It began with E.ON Nordic's decision to leave the consortium in October 2012 and sell off its 34 percent stake in the Fennovoima plant. This decision was purportedly driven by a desire to focus its attention on its investments in Sweden and Denmark. E.ON

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[115] Outokumpu Oyj, a manufacturer of stainless steel was the largest shareholder after E.ON Nordic. Outokumpu Oyj also happens to be the largest consumer of electricity in Finland (Syri et al. 2012). Rautaruukki Oyj (now part of the Swedish firm SSAB) is another example of a major steel manufacturer that has an ownership stake in the Fennovoima consortium.

[116] The DiP represents more than a technical question concerning the need for more electricity. The broad interpretation of the 'overall good of society' derived from the *Nuclear Energy Act* gives the Finnish Government considerable flexibility in the projects it approves and rejects. In the case of the three 2010 DiP applications, the MEE had recommended to the government that they only approve one of them based on the technical criterion of need (J. Aurela pers. comm.). Clearly political factors like support for Finnish industry and concern over regional development played a significant role in Parliament's final decision to approve the two projects.

had already been forced to abandon another proposed reactor in the UK. Both of these decisions can in part be attributed to the economic fallout E.ON was experiencing as a result of the nuclear phase-out in Germany and the ongoing financial crisis at the time (WNN 2012). Fennovoima would need a large investor to fill this void if the capital-intensive project was to remain on track. Fennovoima remained committed to the project and sought to find new ways of financing the NPP. While Areva and Toshiba had initially been considered as potential suppliers for the Fennovoima NPP, the need for a high level of financing from the plant supplier forced the consortium to consider alternatives.

Rosatom, the Russian state-owned nuclear vendor, seeing an opportunity to export a reactor to a Western European country, offered its services. In December 2013, Rosatom offered to build the reactor, a VVER-1200, along with a commitment take on a 34 percent stake in the project, and provide any level of financing that might be required by the consortium (WNA 2017g). While there remained a dedicated group of Finnish companies willing to advance the project, their ownership stake in the project was dwindling. By February 2014, Fennovoima's Finnish ownership group was comprised of 44 shareholders that only accounted for 50.2 percent of the project. While Rosatom was willing to purchase up to a 49 percent stake in the project, there were concerns that this level of foreign investment would not be acceptable to the Finnish Government (WNN 2014e).

In late March 2014, the shareholders agreed to accept Rosatom's initial offer to take a 34 percent stake in Fennovoima through a Finnish subsidiary, RAOS Voima Oy (WNN 2014d). With a technology selected and a new partner in place, the consortium's revised plans would now require government approval.

A supplement to the original DiP was submitted to the MEE in March 2014. This document detailed the new ownership structure, a specific site for the plant, and the plant design, among other modifications to the original DiP approved in 2010. This process was meant to confirm that these changes were acceptable to the government and still in line with the fundamental requirements of the 2010 DiP (Fennovoima 2014). While concerns were raised about the inclusion of a Russian State Corporation as the single largest shareholder within the Fennovoima project, the plan was nevertheless approved by Cabinet on September 18, 2014 and ratified in Parliament in December 5, 2014.[117] The amended DiP had one important condition: that Finnish ownership reach 60 percent or more (MEE 2014a). The minister responsible, Jan Vapaavuori, suggested that this would be a key prerequisite for the project to proceed, and would need to be verified by the government before the construction license could be granted (MEE 2014b).

The political hurdle of getting a project approved with Rosatom as a strategic partner was no small feat. One of the key justifications for the 2009 DiP application had been to seek greater energy self-sufficiency from Russia and the Nordic Market. Finland wanted to reduce its dependence on natural gas imports from Russia and to limit its electricity imports from aging Soviet-era NPPs. By relying on Rosatom for both financial support and reactor design, it was viewed by critics of the project as a new means of perpetuating Finnish energy dependence on Russia.

According to members of the Green League, there was pressure placed on them and other parliamentarians to keep the project alive in spite of the bad optics.

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[117] On September 18, 2014, the Cabinet voted 10-7 in favour of the project (MEE 2014a). On December 5, 2014 Parliament ratified this decision by a vote of 115-74 (WNN 2014a).

Fennovoima was seen as providing important employment benefits for the region, not to mention critical infrastructure for the Finnish steel industry. Satu Hassi (pers. comm.) notes that "that this is one of the big inconsistencies in Finnish politics," the same politicians who had argued against Russian dependence during the 2010 DiP still voted in favour of the new permit that included Rosatom in 2014. She asserts that the government and industry could conveniently use Russian energy dependence when it suited them as a scare tactic and later embrace them as a technology supplier when deemed politically necessary. According to Green MP Hanna Halmeenpää (pers. comm.), many members of the government have privately conceded to her that they are not in favour of the project, but see it as necessary, and stubbornly vote in favour of the project to support Finnish industry.

For industry stakeholders, they felt that they could breathe a sigh of relief following the 2014 parliamentary vote on Fennovoima. During an interview with a Fennovoima Stakeholder Manager, he stated with confidence that all of the major political hurdles had been successfully overcome, and that even a new government would have little effect on the future of the project. "Obviously nuclear power is always affected by politics; we are not living in a bottle so to speak but let's say that the most critical ones have been overcome [sic]" (T. Huttunen pers. comm.). While Fennovoima had successfully renegotiated the terms of their political DiP by the end of 2014, the domestic ownership requirement would continue to dog the consortium thoughout the summer of 2015.

A key challenge for the Fennovoima group would be securing the 60 percent threshold for domestic ownership as set out in the December 2014 amended DiP. A

deadline for Fennovoima to demonstrate compliance with this ownership criteria was set for June 30, 2015 by the Finnish Government.

Fennovoima was struggling to attract investors to a multi-billion dollar project not expected to start electricity production until at least 2024 (Fennovoima 2014). This made it difficult for small utilities and retail players to support the project given the high capital cost and long lead-time associated with the NPP. It was becoming increasingly clear that a larger Finnish company might have to step in to solve Fennovoima's ownership problem.

To that effect, Fortum committed to purchase a 15 percent stake in the consortium in December 2014. Their investment was contingent on being able to secure the purchase of some hydro assets in Northwestern Russia. Fortum, in partnership with Rosatom, were seeking to secure hydro plants from a division of Gazprom undergoing restructuring (WNN 2014b). Fortum appeared to be using the Fennovoima investment as leverage in their negotiations to acquire power plants in Russia. As the June 30 deadline approached, it was becoming clear that this deal would not be finalized in time and Fennovoima risked breaking the terms of their amended DiP. Without a firm commitment from Fortum, Fennovoima filed its construction licence on June 30, 2015, claiming to have reached the requisite level of Finnish ownership (WNN 2015c).[118] In conjunction with the construction application, Fennovoima also submitted to the government a statement of ownership to verify its claim. The Minister of Economic Affairs, Olli Rehn, threatened to derail the process if in fact Fennovoima had failed to meet the requirement for 60

[118] "Domestic" was interpret broadly to include: "parties domiciled in the European Union or a member of the European Free Trade Association" (WNN 2015c).

percent Finnish/EU ownership (ibid.). The Finnish Government wanted to emphasize that the domestic ownership criteria was of the utmost importance, and not a minor bureaucratic matter.

One of the new shareholders that proved to be of particular interest was Croatia's Migrit Solarna Energija, which had purchased a 9 percent stake in the consortium. While the MEE scrutinized this last minute investment in Fennovoima, Finnish media were reporting that the company was a front for Russian capital (Hänninen et al. 2015).[119] Following an investigation by the MEE and the accounting firm Ernst & Young, it was found that the company's roots were in fact Russian in origin and therefore Fennovoima had not met the ownership criteria set out in the amended DiP (Niskakangas and Teivainen 2015). Rather than block the construction application, on July 20, 2015 the government announced that it had given Fennovoima until August 6, 2015 to find a suitable investor(s) to meet this prerequisite (ibid).

On August 5, 2015, it was announced that Fortum had purchased a 6.6 percent stake in the Fennovoima NPP to ensure that the project could continue as planned along with a series of smaller Finnish investors (WNN 2015b).[120] The MEE has since confirmed that Finnish ownership now accounts for 65.1 percent of the project, and has

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[119] The newspaper reported that the Croatian firm had been purchased by Mikhail Zhukov, a Russian construction magnate, who owned a 95 percent stake in the firm, with the other 5 percent being owned by Sberbank, a Russian bank and key creditor for Rosatom.

[120] SRV, a Finnish construction management firm also stepped in and purchased a 1.8 percent stake in the project, and Outokumpu increased its stake from 12.3 percent to 14.1 percent. SRV has also signed a deal with JSC Rusatom Overseas, and the primary subcontractor, Titan-2, to lend its domestic expertise and assist in the construction of the plant. It is unclear whether Fortum's negotiation tactic with the Russians proved successful. There have been no new reports on their Russian negotiations with Gazprom.

allowed the construction licence application to proceed. This process is expected to take up to two years to complete. Construction on the plant is not expected to get underway until 2018.

TVO for its part had sought an extension on its OL4 DiP. The 2010 DiP required TVO to submit a construction license no later than June 30, 2015, something that they were not prepared to do as a result of the long delays that they were experiencing at OL3. Rather than let their DiP expire and be forced to restart the process, TVO sought a 4-year extension on their existing DiP through to March 2019. This extension would have allowed TVO to complete the reactor they had under construction (OL3) before beginning the process of submitting a construction licence for the next unit. This extension was rejected by Cabinet on September 25, 2014 by a vote of 10-3, leaving TVO few options except to allow the DiP to expire in June 2015 with no immediate plans for a new application (WNN 2015d).

TVO has expressed frustration with what they perceive as a "political decision" but remain committed to completing OL3 and assessing the possibility of a new application thereafter (P. Tuohimaa pers. comm.). The President of TVO, Jarmo Tanhua, has echoed this sentiment, suggesting that there is still a need for OL4 in Finland, but concedes that TVO will need to restart the DiP process (WNN 2015d). Whether TVO decides to pursue this course largely depends on the future of OL3.

OL3's Project Timelines: Expectations and Delays

Even under the best of circumstances, timelines for a nuclear project can be quite long. TVO and Fennovoima in their official planning documents assumed their respective projects could take up to ten years to realize. This includes the EIA submission, the

multiple stages of licensing and the construction period. However, in this long and protracted process, projects can be derailed at multiple junctures for a variety of reasons. In the case of OL3, the project has faced a number of construction delays and is now expected to come online by 2018 at the earliest, almost a decade behind schedule.

Delays at Olkiluoto 3

Originally OL3 had been scheduled to be completed by 2009, on a 48-month construction schedule at cost of €3.2 billion (Thomas and Hall 2009). It is now expected to be completed, according to an Areva spokesperson, by late 2018, nine years behind schedule, at a cost of close to €8.5 billion (Reuters 2014). Similar cost overruns and delays have been experienced in France at the Flamanville EPR, which began construction in December 2007 on a 54-month schedule. The Flamanville EPR is now expected to be completed by late 2018, almost six years behind schedule, at a cost of roughly €10.5 billion (WNA 2017a).

Areva, the plant supplier and general contractor on the project, has had to deal with a number of regulatory hurdles that have led to serious construction delays and which have helped to add to OL3's already substantial price tag. Finnish regulators halted construction of the plant for months after it was found that the foundation was poorly laid and welding done on cooling pipes was not meeting industry specifications (Locatelli and Mancini 2012). While Areva has accepted that there have been a number of problems on site with the new EPR design, they contend that the Finns took an excessive amount of time to allow construction to resume (Chazan 2010). Both Areva and TVO are suing each other for damages related to the cost overruns at OL3. The matter is presently before the

International Chamber of Commerce's (ICC) arbitration court, with a final ruling expected in early 2018 (Rosendahl 2014; Rosendahl and Mallet 2017).

Areva has asserted that they were not given the opportunity to work out the kinks in the construction process. The Finnish EPR was being built in Finland with no reference plant to compare it to, with construction starting two years before first concrete on the Flamanville EPR, and three years prior to the Chinese EPRs at Taishan. When construction began on OL3 in August 2005, this was the first new build undertaken by Areva since 1991 (Schneider and Froggatt 2015). New supply chains have had to be forged and new processes worked out for building reactors in the twenty-first century. This 14-year lull in reactor construction was "long enough for a whole generation of craftsmen and managers to have retired and their transmission of experience therefore to have been lost" (Schneider and Froggatt 2015: 60). Areva has since acknowledged that inexperienced subcontractors have led to many of the problems at the Olkiluoto site.

From a regulatory vantage point, Thomas and Hall (2009) note that aside from the challenges associated with approving and completing a FOAK plant, this had been the first new design approved by STUK in almost 30 years. In speaking with the regulator, this argument was flatly rejected. A Project Manager at STUK responsible for OL3 asserted that while they had not licensed a new reactor in some time, they had continued to be active as an agency given Finland's four operating reactors that required periodic safety reviews, lifetime extensions, and renewed operating licences (M. Tuomainen pers. comm.). For the regulator, the issues they encountered with the EPR had more to do with the incomplete elements of its design and the initial difficulty they had with Areva

acclimatizing to the Finnish regulatory environment.[121] These complaints were echoed by my discussions with TVO as well as the MEE. Minna Tuomainen (pers. comm.) describes Areva as a company that seemed unprepared or unaware of the need to adapt to a new regualtory environment:

> In the beginning the challenge was that Areva did not know the Finnish Safety requirements and it took some time before they understood what kind of regulatory framework there is in Finland, and what is the role of the regulator and what really are the requirements. It was a bit surprising to us that they did not know all the requirements, even the main requirements before [beginning the licensing process]. I think that was the main challenge when working with Areva.[122]

While the relationship between Areva and STUK has shown improvement, delays have continued as a result of a lack of familiarity with Finnish regulatory principles. Tuomainen (pers. comm.) notes that while Areva has been quick to address a specific technical problem flagged by STUK, they have often failed to appreciate what might be required to bring the rest of their work into line with the higher principles outlined by

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[121] One significant source of delay was the introduction of a digital Instrumentation and Control (I&C) System. Tuomainen (pers. comm.) concedes that this was one element that STUK lacked experience with, and one which had not been considered in past licesnsing submissions. Finland was not alone in this criticism. Regulators from France and the UK also sought greater clarity on the design and safety case for the I&C system on the EPR. It was approved by STUK in April 2014, a process that took almost five years to resolve. For a brief discussion of the I&C issue see: (WNISR 2014). OL3 has been fortunate not to have encountered problems with their reactor pressure vessel (RPV) thanks to the use of a Japanese supplier (Thomas 2015; Marignac 2015). EPRs which used a French-built RPV like those in France and China will likely experience far costlier repairs and rework to address the issues related to their defective forging. Other French forgings continue to be scrutinized by STUK to ensure that Finnish nuclear safety is not compromised (WNN 2017c). Areva's Le Creusot forge, a key supplier of parts for the French nuclear supply chain, has come under scrutiny for poor record keeping, forged documents, and faulty manufacturing. The implications of this are not yet known for OL3.

[122] A TVO representative echoed this sentiment, suggesting that while Areva has complained about how strict STUK had been, in practice the issue has had more to do with Areva adjusting to the nuances of the regulatory culture that exists in Finland (P. Tuohimaa pers. comm.).

Finnish safety requirements. These errors were further compounded by incomplete design elements of the EPR. This was something STUK had failed to catch during the construction licence application process. The design has since required costly design changes which have led to further delays. Even when these errors were corrected for, poor on-site management meant that this information was not always properly relayed to the appropriate tradespeople or subcontractors. Repsonsibility on-and off-site was not always clearly defined, reiniforcing a culture of poor communication and coordination (ibid.). Having learned many lessons from OL3, STUK expects to be better prepared to assess the merits of Fennovoima's construction licence over the next two years.

In summary, problems at OL3 stem not only from issues pertaining to a loss of manufacturing and engineering skills needed to build a nuclear plant and the issues related to a FOAK design, but also challenges on the part of Areva adjusting to a new regulatory environment. While not without their own site-specific problems, it does appear that the Taishan EPRs (in China) have benefitted from the lessons learned from OL3 and Flamanville. The EPR continues to be the flagship reactor design for the French industry. In September 2016, Areva, in partnership with EDF, began construction of a new EPR in the UK at Hinkley Point C, and have plans for additional exports to India and China in the near term.[123] Hinkley Point C is not expected to come into service before

[123] It is worth noting that the financial challenges associated with the EPRs, along with forging problems at Le Creusot have forced Areva to be restructured. In November 2016, it was announced that EDF, the operator of France's reactor fleet, would take a controlling interest in Areva's reactor business through a joint-venture known as New NP (WNN 2016b). The French Government will be providing $4.8 billion in financial support to help facilitate this restructuring process.

2025, providing a far more realistic construction timeline than what had been envisioned for earlier EPRs (Moylan 2016).

Fennovoima: Potential for Delays at Hanhikivi

In the case of Fennovoima's project, it should benefit from an experienced supplier in Rosatom, which will have had recent experience seeing an AES-2006 plant through to completion. Currently four plants of this design are under construction in Russia. However, it appears that they too are facing delays. Construction started at the reference plants in 2008 at Sosnovy Bor, also known as Leningrad Phase II NPP. While the first of the VVER-1200 units was to go critical at the end of 2015, commercial operation is now slated to begin as late as 2018 -- three years behind schedule (Thomas 2015). That being said, the reference plant is still expected to be completed before construction work begins at the Hanhikivi site in Finland. Fennovoima expects to benefit from a completed reference plant that will bring with it proven manufacturing techniques, a complete supply chain, and an experienced subcontractor -- Titan-2, the general contractor for the plant (Huttunen pers. comm.). This experience will inform Fennovoima "how long these [construction] phases actually take, so that [they] can formulate a realistic schedule for the project itself" (ibid.). In an interview with one of Fennovoima's Stakeholder Managers, it was made clear that this experience was what set Rosatom apart from other potential plant suppliers. They were keen to select a partner who had recent experience seeing a project through to completion from first concrete to grid connection to avoid some of the pitfalls experienced by other utilities.

What other sources of delay might Fennovoima face as its project moves towards the construction phase? While the question remains highly speculative, a variant of it was

posed to the stakeholders interviewed in Finland. Of particular interest were the challenges a new utility company might face in building its first NPP and the additional issues that might arise at a greenfield site, a community with no history of hosting a nuclear facility of any kind. In terms of capacity-building within Fennovoima, the company has remained quite small. They have expanded from approximately 100 staff in 2014 to 300 by the end of 2015 (ibid.).[124] STUK has raised concerns over the high turnover rate at Fennovoima and the general competence of such a new and relatively small utility:

> There are some very competent persons working there [at Fennovoima] but the number of people has been quite low….It takes some time before they can really gather the competence within the company itself. And this is something we [STUK] are really quite worried about (Tuomainen pers. comm.).

Relative inexperience may mean that Fennovoima allows Rosatom to have more influence on important decisions moving forward.[125] Fennovoima has for its part continued to develop the company in an effort to meet all of the concerns of the regulator, and to impress upon them that they have sufficient expertise and competence to manage a project of this size and scope (Huttunen pers. comm.).

Social Acceptance and the Politics of Opposition

The role of social acceptance and the public has been somewhat muted in this chapter. While it was noted that politicians were concerned about social acceptance, particularly during the 1993 DiP, it was not an issue that seemed to have as much traction

[124] At the time of the interview (March 2015) Huttunen noted that Fennovoima had 166 staff.

[125] This was a problem for TVO, which had a very limited role in the project management of OL3 given its turnkey nature. As a result, it was unable to direct Areva in ways that might have helped to mitigate the regulatory difficulties that they encountered early on (Tuomainnen pers. comm.).

in later DiPs. There are two things in particular worth noting about the Finnish public that may help to explain their limited input on the issue. One is the high level of trust in science and expertise, and the other is the corporatist approach to governance in Finland that tends to limit public input.

Public opinion research in Finland has shown a relatively consistent trend towards an increase in support for nuclear power from the 1982 to 2003 (NEA 2010). A 2014 industry-commissioned Gallup poll suggested that 41 percent of Finns held a positive view of nuclear energy, while only 24 percent held a negative view, a number consistent with the level of support that existed at the beginning of the nuclear renaissance (WNA 2017g; NEA 2010; WNN 2010). An October 2014 poll commissioned by Fennovoima in Pyhäjoki, the site of the proposed Fennovoima NPP, suggests that 67 percent of its residents are in favour of the project (Fennovoima n.d.). By contrast, a 2015 poll conducted by Taloustutkimus, commissioned by the World Wildlife Federation (WWF), suggests that only 29 percent of Finns wanted the government to approve the Fennovoima project, with a majority (51 percent) preferring the government vote against it (YLE 2015b).[126] Many of the people I interviewed for this dissertation raised the question of opposition to the Fennovoima project in one form or another. Opposition to the Fennovoima project is at the very least more organized and visible than any other anti-nuclear effort in Finland.

Environmental groups like Pro Hanhikivi have complained that industry polls are skewed and do not accurately reflect the level of opposition to the project in the region.

[126] The poll asked: “Do you think the government should grant building permission for the current Fennovoima nuclear power plant project?" The options were "yes," "no" or "I couldn’t say."

They have repeatedly called for a local referendum on the project to give the local people a stronger voice in the decision-making process, but this proposal has been rejected on four separate occasions by the municipal council in Pyhäjoki (Halmeenpää pers. comm.).

It is unclear whether public opposition would necessarily have a strong influence on energy policy in Finland. Energy policy in Finland appears to be insulated from public opinion in a variety of ways. A 2013 study found that Finns have traditionally had a lower level of opposition to nuclear power than what is found in other countries.[127] Ilkka Ruostetsaari's (2013) findings suggest that Finns prefer expert-driven science and technology (S&T) policy, with 9 out of 10 respondents affirming this position. Their preference for experts over politicians reflects a belief that experts are more likely to do what is in the best interest of Finland as opposed to politicians. Ruostetsaari (2013) contends that the public does not necessarily want more input on these issues; instead, their preferences suggest a desire for a more consensus-driven energy policy informed by objectivity and expertise. Their general trust in science and expertise is, according to Tuula Teräväinen et al. (2011: 3441), the result of a "lack of a critical public sphere," within a corporatist state that has led to a "technology-and-industry-know-best" orientation. It is not a political environment that encourages dissent, particularly on science-based issues thought to be best left to the experts.

This characterization of a somewhat docile public speaks to Finland's political culture. Antti Pelkonen (2008) suggests that their political culture reflects a market-oriented corporatist approach to governance that does not encourage the public to

[127] The study included 4000 Finns contacted between May and October 2007 through a mail-in survey (Ruostetsaari 2013).

challenge authority. This approach "tends to pull away from the public arena. [A] corporatist mode of governance implies a closed process of deliberation and negotiation between the privileged stakeholder groups" (Pelkonen 2008: 404). The decision-making process is driven by a small group of elite policymakers and industry stakeholders, a group whose membership has been remarkably stable over time (Ruostetsaari 2010). Satu Hassi (pers. comm.) notes that the elite of Finland are a relatively "close network of friends" with leadership roles in industry, the media, and politics. These men belong to social clubs where they forge bonds that go beyond their specific industry, serving to facilitate and perpetuate this insider/outsider dynamic. This approach to energy policymaking and governance has served to limit the role of the public and civil society groups interested in influencing Finland's nuclear energy policy. As a result of their political culture, it has been noted that Finnish civil society is more cooperative with existing stakeholders as it works to gain access to a consensus-driven political process.[128]

While civil society groups are now regularly included in government consultations, it does not mean that they have a high degree of influence over the process. Ruostetsaari (2010) classifies them as "outsider groups" that hold little sway over the final outcome of energy policy. This is a position that was echoed by those that I interviewed. Hanna Halmeenpää, Vice-President of Pro Hanhikivi and a Green Member of Parliament, suggests that concerned Pyhäjoki residents were being allowed to voice their concerns in official forums along with other Green NGOs but that their views were not taken seriously. "They are heard, but they are mainly only heard. You can say what

[128] Ruostetsaari (2010) notes that it has taken time for international NGOs like Greenpeace to get acclimatized to the Finnish political environment. They have been forced to tailor their lobbying efforts to a more consensus-driven process.

you think about it but it does not affect their decision-making" (Halmeenpää pers. comm.). According to Halmeenpää, policymakers enter these processes with their minds already made up, making it difficult to persuade them that there are viable alternatives to nuclear power. Perhaps what is more problematic for green NGOs is that the public is not critical of the message presented to them by industry and the MEE. Halmeenpää laments that the public's high level of trust in public officials has made them complacent and reluctant to challenge local politicians on the issue of nuclear power. A symptom of this complacency is the lack of a protest culture. In Finland, political demonstrations are rare, and when they are held they tend to be quite small. "Finnish people don't demonstrate. It is actually useless to organize demonstrations in Finland… you do not get people out in the streets. It's not our culture" (Halmeenpää pers. comm.). Given the rarity of these events and their small size, they are unlikely to have a significant influence on policymakers or the broader public. A number of stakeholders noted that there has been a far more organized response to Fennovoima, but it remains to be seen if public opposition will serve to have any significant influence on the Hanhikivi NPP or Finnish nuclear policy more generally speaking.

A Uniquely Finnish Approach to Nuclear Opposition

In order to gain influence and credibility in Finland, environmental groups have shifted the tone of their anti-nuclear stance. In a country where policymakers have made tangible efforts to address longstanding concerns over waste and safety, critics have had to find new grounds for effectively challenging the government's nuclear policy. The emphasis of their messaging began to shift towards the poor economics surrounding nuclear power, in particular as an investment for Finland, and the ever-present concern

over Russian involvement in the Fennovoima NPP.[129] This was a shift that started with OL3 in the early 2000s and has continued through to the more recent debates over the Fennovoima project.

In my interviews, I asked environmental groups why they were focused on the poor economics associated with nuclear power and Russian participation in the Fennovoima project instead of more traditional concerns like safety, weapons proliferation, and waste. The general response I received was that they were speaking to policymakers and the public in a language that would resonate with them on issues that mattered to them. Waste and safety were no longer effective means of challenging pro-nuclear rhetoric in Finland. Green NGOs believed that there was a need to highlight more tangible reasons for rejecting nuclear power as an option for Finland.

Halmeenpää (pers. comm.) asserts that for Pro Hanhikivi it was more effective to discuss the economics and geopolitical issues surrounding the Fennovoima NPP rather than raise more traditional concerns:

> If an NGO starts to point out only the environmental risks or nuclear weapons, it is useless in Finland, no one would listen and no one would take you seriously. Even though it is true, it is there, the environmental risks and all that…politicians and decision-makers…do not take you seriously if you do not point out the economic reasons and that sort of stuff [*sic*].

[129] Examples can be found at: (Pro Hanhikivi n.d.). Greenpeace Finland has more traditional concerns outlined on their website but does have a prominent section dedicated to nuclear power's poor economics, see: (Greenpeace Finland 2013). International environmental groups often now use the economic argument against nuclear power (see for example the annual World Nuclear Industry Status Reports), but the Finnish variant seems to emphasize these issues to the exclusion of others in recent years, in a way I have not seen in other countries. The moral argument against nuclear power appears to have been superseded by the economic argument.

So there is both a desire to be taken seriously by politicians as well as a concerted effort to speak to everyday Finns about issues that matter to them. Keep in mind that these projects, using the Mankala Principle, are seeking investment not just from major industrial players, but also municipalities and small businesses across the country. So in challenging the business case for an NPP, they are raising concerns for the taxpayers of the neighbouring municipalities and community members that have decided to personally invest in the project.

Part of the problem with this messaging has been that it has been difficult for green NGOs to claim to have a better grasp of the industry than the government or the utilities themselves. Green NGOs have also been unable to present a positive alternative that effectively challenges the pro-nuclear narrative. The industry's business case for new NPPs has been based on its growing demand for electricity, which is seen as a net positive for the country. It means that exports, employment, and the economy in general are healthy and growing. By contrast, environmental groups that challenge this narrative are put in a tough place, because, if their claims are to be believed, it means that the Finnish economy is not as strong as the government and industry are saying that it is, potentially having serious ripple effects for communities reliant on them for employment. During the lead-up to the 2010 DiPs, this counter-narrative, while perhaps intellectually honest, was not one the public wanted to entertain given their reliance on the health and stability of these large employers within their respective communities (Anonymous pers. comm.). An anonymous activist noted that green NGOs should have had a greater sensitivity to the concerns of the public and how the public might respond to this critique of the industry.

This is perhaps one of the key lessons learned for environmental groups in Finland: the need to present not only a relevant, but also a positive alternative to the arguments advanced by industry. We can see the first signs of this change in the new *Energiaremontti* campaign.[130] The emphasis of this campaign is on promoting an economically and environmentally advantageous renewable future for Finland that does not exclude Finland's existing NPPs (Energiaremontti 2015). The campaign calls on Finland to phase out coal by 2025, and other fossil fuels by 2035, as it transitions to a renewable supply-mix by 2050. What is interesting about the campaign is that it "does not strive to alter granted licenses for nuclear power plants nor does it aim to shut down current power plants" (ibid). It is a pragmatic effort to promote their sustainability agenda, while avoiding the unconstructive debates of the past that focused exclusively on the negative elements associated with nuclear power development.

The failure of past campaigns has led green NGOs to develop and refine their public relations strategies in interesting and innovative ways. There is an ongoing effort on the part of environmental groups in Finland to tailor their messaging to their audience. In doing so, they have demonstrated a pragmatic strategy where they have been willing to divest themselves of old, ineffective messaging in an effort to spur a genuine national dialogue when it comes to an energy transformation. Green groups are increasingly framing the national conversation as one where Finland can stay the course and continue to invest in additional NPPs or choose as a society to transition to renewables and "start to modernize the energy production system in Finland" (Halmeenpää pers. comm.). Their claim is that the business case should drive these political decisions; which to date has

[130] *Energiaremontti* is Finnish for energy renovation.

not been terribly favourable for new nuclear reactors in Finland. Whether this strategy will prove effective in the years to come remains to be seen.

Conclusion

This chapter has sought to highlight some of the contributing factors that have led to the expansion of nuclear power in Finland since 2000. It has focused on the close relationship that exists between the state and the nuclear industry; the role of the Mankala Principle in facilitating the financing of new builds; the political approval of a waste repository; the limited engagement of the public in the realm of energy policy; and the marginalization of opposition groups within the national debate that have all contributed to this era of nuclear expansion.

What we have seen in this relatively politically permissive environment for nuclear power is that not all projects that are proposed are approved, nor will those that are approved necessarily be completed. Since 1986, there have been efforts to get a fifth NPP built in Finland. After three attempts to get a DiP passed by the government, OL3 received approval in 2002, one year after the approval of an industry-owned waste repository. But the political permission to build a reactor is only one of many steps needed to complete a new build. OL3 has highlighted just how difficult it is to get a reactor from the planning to the operational stage of development. This project has been plagued by a series of political, regulatory, and technical challenges that have kept the reactor from being completed in a timely manner. In spite of the significant delays and cost overruns, Finland is expected to have its fifth NPP completed in late 2018.

In the case of Fennovoima, we have seen how a politically permissive environment does not necessarily make it any easier for a utility to raise the capital

necessary for a new reactor. Even with the assistance of the Mankala Principle, they have had to replace their largest investor, E.ON Nordic, and struggled to maintain sufficient domestic investment necessary to meet the DiP's ownership requirements. The Finnish Government's decision to grant Fennovoima a brief extension to find new investors speaks to Finland's desire to see this project through to completion. The challenges Fennovoima might face during the construction phase of its project remain to be seen. Construction on the Fennovoima NPP is not expected to begin until 2018.

Finland was one the first countries to test the waters of the so-called nuclear renaissance. This era of nuclear expansion had held the promise of increased performance and profitability for the next generation of reactors. It was expected that new manufacturing techniques, in conjunction with improved designs, and project management would lead to better results for new builds right out of the gate. To date, the Finnish experience has shown that cost and construction timelines for nuclear are nowhere near industry expectations, and are showing only limited signs of improvement.

Finnish utilities have demonstrated that under the right conditions it is still possible to secure the necessary political, economic, and social support needed to build a reactor in a Western-democratic state. But well-heeled consortiums capable of enduring these lengthy delays may in fact be outliers in an increasingly competitive electricity market where alternatives can be built with fewer political obstacles, on a faster timetable, and at a fraction of the cost.

It is important to note that this chapter's emphasis on the DiP and the national political debate surrounding nuclear power does not tell the whole story. The role of the local community and the specter of undue Russian influence in Finnish affairs is

obscured by a national discussion of nuclear energy policy. The basis of social acceptance relies on the local community just as much as it does on a DiP from Parliament given their veto over siting process and their role as a potential investor in the project itself (Tuohimaa pers. comm.). A more in-depth study on the role of local acceptance at the municipal level might highlight other elements of the debate not discussed in this chapter.

The energy debate in Finland has long used Russia as a foil when it discusses the need for energy security. The inclusion of Rosatom in the Fennovoima project adds a wrinkle to this long-standing narrative, one that has been difficult to spin as a net positive for the Finnish consortium. The role of Russia in shaping Finnish energy policy is something that was not considered when this study was designed but it is clearly something that merits further study.

Chapter 5: Maintaining Capacity in Canada

Today there are 19 reactors operating in Canada, 18 in Ontario, and one in New Brunswick. Together, they account for roughly 16 percent of the country's electricity supply (WNA 2017f). In Canada, decisions regarding the supply of electricity remain the purview of the provinces, while nuclear power as a technology and all elements of the fuel-cycle are regulated at the federal level. This chapter will focus on Ontario, the province with the largest number of reactors, and the greatest reliance on the technology. Ontario is one of the earliest adopters of commercial nuclear power in the world and has remained committed to the technology for decades. Since the turn of the century, Ontario's energy policies have demonstrated a clear commitment to nuclear power. This is evidenced by the restarts of six laid up units at Bruce and Pickering and the planned refurbishment of ten units at Bruce and Darlington. That being said, efforts to build two new reactors at Darlington have been frustrated at every turn since they were first proposed in 2006. This chapter explores some of the factors that led the province of Ontario to defer its plans for new construction while continuing to pursue refurbishment. These factors include: the high cost of new construction, a revised forecast for the province's electricity demand, and a dispute between the federal and provincial government over who should assume the risk associated with building a reference plant for a new design. The remainder of this chapter explores issues related to the Darlington Environmental Assessment (EA) and the Judicial Review that it faced in 2014. It also looks at how questions of social acceptance have been advanced by environmental groups and the response that this has elicited from the nuclear industry and the regulator.

In the case of nuclear waste, like Finland, a DGR remains the preferred means for addressing the long-term issue of HLW. That being said, early efforts to build such a facility have been delayed. The ongoing efforts by the federally mandated Nuclear Waste Management Organization (NWMO) to find a socially acceptable means for handling HLW will be discussed in this chapter. The issue of waste provides some insights into the challenges the industry faces when trying to secure social licence from a host community.

In this chapter, we see how changing circumstances shape these long-term policy decisions. Ontario is continuing to invest billions of dollars in maintaining nuclear power as a staple of their electricity supply mix in spite of being unable to build a new plant. This chapter attempts to discern some of the factors that have led Ontario to support refurbishment over new builds during the period of study. As we will see, there is no explicit policy decision that leads to this outcome but a confluence of factors that emerge over time.

Background: A Brief History of Ontario's Nuclear Power Program

While Canada's nuclear program has its roots in the Second World War, its power program emerged during the 1950s. Atomic Energy of Canada Limited (AECL) was a crown corporation that was formed in 1952, largely in response to the potential commercial applications derived from the National Research Experimental (NRX) reactor and other projects that were operating or under development at Chalk River Labs (Doern 1980). By 1954, AECL was carrying out its first feasibility study into building a prototype reactor for nuclear power generation. This study led to the construction of the Nuclear Demonstration Plant (NPD) in Rolphton, Ontario. This was a collaborative effort between the provincial utility, the Hydro-Electric Power Commission of Ontario

(HEPCO) and the Federal Government represented by AECL (deLeon 1979). The 22-MWe NPD was a heavy-water reactor that borrowed elements in design from the NRX research reactor and would lay the foundations for future Canada Deuterium Uranium (CANDU) reactors. By 1959 AECL had committed to building a 200-MWe plant at Douglas Point in partnership with HEPCO.

These two projects laid the groundwork for the adoption of the CANDU reactor system as the template for future nuclear power plants in Ontario. It also led to a long-term partnership, between AECL and HEPCO (later known as Ontario Hydro), the province's integrated utility company (deLeon 1979).[131] Ontario Hydro was an early investor in CANDU technology and ultimately proved to be AECL's most loyal customer. Ontario Hydro ordered 20 units[132] at three sites from 1964 to 1977.[133] Ontario Hydro was the sole operator of commercial nuclear power plants in the province until the market was restructured in the late 1990s.

Changes to the Electricity Market

Today, while the provincial government remains a strong player in the electricity sector, there have been efforts to move towards a more liberalized market. Restructuring began in 1998 with the passage of the *Electricity Act*.[134] The plan was for a staged restructuring that would begin by separating the province's transmission assets from its generation assets. In 1999, the newly formed Ontario Power Generation Inc. (OPG) took

[131] HEPCO became Ontario Hydro in 1974.
[132] The 20 units exclude the NPD and Douglas Point reactors which were owned by AECL and operated by Ontario Hydro. The subsequent units were owned and operated by Ontario Hydro.
[133] These units came online between 1971 and 1993 (Bratt 2012).
[134] For the text of the legislation, see: (Ontario Legislative Assembly 2017).

control of the province's generation assets, including all of its nuclear, coal, and hydro power plants. At that time, OPG, a wholly-owned provincial crown corporation, held 90 percent of Ontario's electricity generation portfolio (Trebilcock and Hrab 2005). Transmission assets were given to the newly minted Hydro One Inc. To open the market up to greater competition as part of the restructuring OPG had to sell "65 percent of its price-setting generating units within the first three-and-a-half years after market opening, and 65 percent of its core, or base-load, facilities within ten years of market opening" (Trebilcock and Hrab 2005: 125). This requirement led to the creation of Bruce Power.

In July 2000, it was announced that the eight units at the Bruce site in Tiverton, Ontario (Bruce A and B) would be leased to a consortium led by British Energy through to 2018, with the possibility of a 25-year extension (PEI 2000). At the time, the consortium included the uranium mining company Cameco, as well as the Power Workers' Union and the Society of Energy Professionals. Since then the ownership group at Bruce Power has changed. In 2002, British Energy sold its stake in Bruce Power to a consortium that now had grown to include TransCanada Pipelines and what is known as Borealis Infrastructure.[135] Cameco sold its share in the Bruce A units in 2005, and left the consortium all together in early 2014 (Koven 2014).[136] In the lead up to refurbishment,

[135] Borealis Infrastructure invests on behalf of the Ontario Municipal Employees Retirement System (OMERS), a large Canadian pension plan. Borealis is wholly-owned by OMERS.

[136] There had been a different ownership structure in place for the Bruce A units following the decision to refurbish two of them in 2005. This led to the creation of the Bruce A Limited Partnership. Cameco sold its interest in those units at the time. Bruce A LP is comprised of TransCanada, who owns a 47.4% stake, Borealis Infrastructure with a 47.4% stake, and the Power Workers Union and Society of Energy Professionals with the remaining 5.2% (Office of the Auditor General 2007). As part of the 2015 amendment to their long-term agreement with IESO, Bruce Power will return to a single partnership structure (WNN 2015a).

TransCanada bought additional shares from Borealis in December 2015. Each will now hold 48.5 percent stake in the restructured single partnership, with the Power Workers' Union and Society of Energy Professionals owning the remaining 3 percent (WNN 2015a).

As of 2016, Bruce Power operates eight of Ontario's reactors, while OPG operates ten (six at Pickering and four at Darlington). These reactors account for 36 percent of Ontario's supply mix (12 978MW of installed generation capacity), and provide up to 60 percent of Ontario's electricity at any given time (IESO 2017b).

While Ontario's electricity system exhibits some elements of a liberalized market, it is best characterized as a hybrid system. While a wholesale electricity market has been in place since 2002, it remains highly regulated. A large portion of Ontario's electricity supply is under long-term contracts with the province's Independent Electricity System Operator (IESO).[137] Those contracts provide a fixed/guaranteed price to generators, to protect them from market fluctuations and to encourage investment in certain types of power generation. IESO also operates the wholesale market where a bidding system helps to establish the hourly rate for other generators. Since 2012, IESO has taken over the role of the Ontario Power Authority (OPA). This has meant that IESO is also responsible for short, medium, and long-term forecasting of Ontario's electricity needs, to ensure that the province has an appropriate supply mix to meet its future needs (IESO 2017a). To assist in this process, IESO produces a 20-year plan for the Ministry of Energy offering technical advice on the province's future needs. They also sign long-term supply

[137] Formerly known as Independent Electricity Market Operator (IMO) until 2005. These long-term supply contacts provide a fixed price for generators, and are in place for on average 20 years.

contracts with generators to help ensure that those long-term needs are met. Ultimately the province's Ministry of Energy determines which projects will go ahead. Since 2010, the Ministry has produced a policy document known as the Long-Term Energy Plan (LTEP), which in practice sets out the government's 20-year plan for the electricity supply mix (MOE 2010; MOE 2013; Auditor General of Ontario 2015). The LTEP has in many ways come to replace the technical plans produced by the IESO/OPA as the principal policy document guiding Ontario's electricity planning. The role of the Ministry of Energy and the LTEP will be something revisited later in the chapter.

While Ontario has had nuclear power as part of its supply mix for decades, its future has not always been as certain. This next section explores some of the challenges Ontario's nuclear fleet faced in the lead up to the province's electricity market restructuring, and the early signs of a potential recovery.

The Ups and Downs of the Ontario Nuclear Fleet

The 1990s had been a difficult decade for nuclear power in the province. AECL and Ontario Hydro had experienced costly delays in the construction of the Darlington NPP, driving up the initial cost from $7.4 billion in 1978, to $14.5 billion in 1993 when the four units were completed (Bratt 2012; Whitlock 2011).[138] From 1995 to 1998 Ontario Hydro was forced to shut down 8 of its 20 units due to poor operation and maintenance practices (WNA 2017f). These shutdowns led to a temporary increase in the

[138] Tom Adams (2000) and Mark Winfield et al. (2004) cite a lower starting figure for the Darlington NPP of $2.5 billion which has since been reproduced in several places (Cadham 2009; Trebilcock and Hrab 2005; Durant 2009). The discrepancy seems to exaggerate the cost overruns experienced at Darlington. The earliest figure I have been able to find comes from a secondary source who interviewed an Ontario Hydro Project Manager in 1982 (Keng 1985). This figure aligns more closely with the higher estimate noted above.

use of coal in order to make up for the 5000 MWe of generating capacity that had gone offline (Cadham 2009). Nuclear power was blamed by many as a costly technology that had left Ontario Hydro saddled with a staggering $38.1 billion debt (Trebilcock and Hrab 2005). Nuclear power was coming to be seen as both a costly and unreliable way of meeting the province's electricity needs.

When OPG was created in 1999, Ontario Hydro's debt was removed from its books, to be independently managed by the newly formed Ontario Electricity Financial Corporation (OEFC). The stranded debt (or unfunded liability) of $19.4 billion would be paid down through the profits derived from OPG and Hydro One. A fee was also applied to the ratepayer's monthly bill to help service the debt (Office of the Auditor General 2011).[139] The poor state of Ontario Hydro's finances in conjunction with the challenges facing its nuclear fleet at the time appeared somewhat dire for the industry.

Better management and operation of the province's nuclear fleet following the restructuring of Ontario Hydro led to optimism that the industry might be able to make a comeback of sorts. While a far cry from a nuclear renaissance in the province, Michael Blake (2005: 32) asserted that the Canadian industry was experiencing a "reawakening" as laid up units were reassessed and slowly restarted by Bruce and OPG in the early 2000s.

Early efforts in the province focused on getting the eight shut down units back up and running. From 2003 to 2012 six of the eight units laid up during the 1990s were

[139] Ontario Hydro's assets were assessed at $17.2 billion in 1999. The stranded debt represented "the total debt and other liabilities of Ontario Hydro that could not be serviced in a competitive environment" (Office of the Auditor General 2011: 122). As a result, the OEFC was brought in to manage that debt.

returned to service; two units at Pickering A, and all four units at Bruce A (WNA 2017f). Nuclear power had become an important tool to help fulfill a 2003 election promise by the province's newly elected Liberal Government to phase out the use of coal. In June 2006, the Ministry of Energy formally issued a Supply Mix Directive calling on the OPA to phase out coal in favour of cleaner sources of electricity (Office of the Auditor General 2015).

Today the province is on the precipice of undertaking another ten refurbishment projects, identifying nuclear power as "the backbone of Ontario's [electricity] supply" (MOE 2013: 3). While new builds were seriously considered by Bruce and OPG over the course of the last 15 years, the province has since shelved these ambitions. This chapter intends to unpack the factors that served to shape Ontario's continued commitment to nuclear power through refurbishment. In particular, what led the province to support nuclear power through refurbishments, but not new builds? The next section will outline in greater detail the stakeholders involved in this process, before delving into the case study of Darlington.

Table 4: Ontario's Operating Nuclear Fleet (as of 27 June 2017) [140]

Name	Utility	Supplier[141]	Type/Output	Ordered	CO.[142]
Pickering-A1	OPG	OH/AECL	PHWR-515 MWe	1964	1971
Pickering-A4	OPG	OH/AECL	PHWR-515 MWe	1965	1973
Pickering-B5	OPG	OH/AECL	PHWR-516 MWe	1974	1983
Pickering-B6	OPG	OH/AECL	PHWR-516 MWe	1974	1984
Pickering-B7	OPG	OH/AECL	PHWR-516 MWe	1974	1985
Pickering-B8	OPG	OH/AECL	PHWR-516 MWe	1974	1986
Darlington-1	OPG	OH/AECL	PHWR-881 MWe	1977	1992
Darlington-2	OPG	OH/AECL	PHWR-881 MWe	1977	1990
Darlington-3	OPG	OH/AECL	PHWR-881 MWe	1977	1993
Darlington-4	OPG	OH/AECL	PHWR-881 MWe	1977	1993
Bruce-A1	Bruce Power	OH/AECL	PHWR-750 MWe	1968	1977
Bruce-A2	Bruce Power	OH/AECL	PHWR-750 MWe	1968	1977
Bruce-A3	Bruce Power	OH/AECL	PHWR-750 MWe	1968	1978
Bruce-A4	Bruce Power	OH/AECL	PHWR-750 MWe	1968	1979
Bruce-B5	Bruce Power	OH/AECL	PHWR-825 MWe	1975	1985
Bruce-B6	Bruce Power	OH/AECL	PHWR-825 MWe	1975	1984
Bruce-B7	Bruce Power	OH/AECL	PHWR-825 MWe	1975	1986
Bruce-B8	Bruce Power	OH/AECL	PHWR-825 MWe	1975	1987

[140] Unit 2 at Darlington began a 42-month refurbishment in October 2016 (WNA 2017f). Pickering units A2 and A3 were never restarted following their shutdown in 1997.
[141] In the case of Ontario's reactors, they were all supplied by AECL in partnership with Ontario Hydro.
[142] Commercial operation began in this year.

Key Stakeholders and the Decision-Making Process

Government

Within the Canadian decision-making process, electricity generation (policy and planning) is the purview of the provinces, while nuclear power and uranium are the responsibility of the Federal Government. In practice this means that the Government of Ontario ultimately decides whether or not to adopt new capacity and makes all important decisions regarding its electricity supply mix. The Federal Government by contrast is responsible for the regulation of the technology itself. Both levels of government conduct research in the area of nuclear energy policy (IAEA 2016a).

At the federal level, Natural Resources Canada (NRCan) is the department responsible for issues related to nuclear energy. NRCan is principally responsible for working on bilateral and multilateral issues related to nuclear power, funding for nuclear R&D, and the development of federal policy related to the technology (NRCan 2015). The Minister of Natural Resources is also responsible for the Canadian Nuclear Safety Commission (CNSC) and the crown corporation, AECL. The Federal Government has traditionally had an important role in R&D through its ownership and management of AECL. Given AECL's historic role as the sole supplier of Ontario's nuclear fleet, the Federal Government has also played an important role in funding the development of CANDU reactors, as well as backing liabilities incurred in the construction and sale of the technology.

As noted above, the provinces ultimately decide what kinds of energy sources to adopt for their electricity supply mix. In the case of Ontario, this portfolio is administered by the Ministry of Energy. They are responsible for developing the province's electricity

transmission and generation assets. While utility companies like OPG and Bruce Power might propose a project to the Ministry of Energy, the final authority rests with the province as to whether or not to advance a refurbishment or new build (P. Tremblay, pers. comm.).[143] The Ministry is also the responsible authority for Hydro One, OPG, IESO, and the Ontario Energy Board (OEB). In partnership with these provincial corporations and agencies, the Ministry is expected to develop and maintain a reliable, clean, and affordable supply mix for the province (MOE 2015).

The Regulator

The CNSC was formed in 2001 as a successor agency to the Atomic Energy Control Board (AECB). The CNSC is the national regulator responsible for regulating all elements of the nuclear fuel-cycle, as outlined in Section 9 of the *Nuclear Safety Control Act*. Given the federal mandate for nuclear energy, there is no provincial counterpart to the CNSC (CNSC 2008a). Their mandate includes the "regulation of the development, production and use of nuclear energy in Canada to protect health, safety and the environment" (CNSC 2014b). The CNSC is comprised of a small legal tribunal known as the Commission that acts as a quasi-judicial agency designed to issue and review licences that cover a broad range of nuclear activities in Canada. The CNSC has a technical staff comprised of almost 800 personnel meant to assist with the reviews undertaken by the Commission providing recommendations that help to inform their decisions (CNSC 2017).

[143] Pierre Tremblay is the former President of Canadian Nuclear Partners (a subsidiary of OPG) and former Chief Operating Officer at OPG.

In the case of a commercial reactor, the CNSC must determine whether the proponent (the utility company) is capable of operating the plant safely, and whether they have "made adequate provision for the protection of safety and the environment and safeguards, security and all those other things" (M. de Vos, pers. comm.). [144] While the reactor design plays a part in the decision, the emphasis is on whether the utility is capable of operating the plant safely over its lifetime. The regulatory process places the onus on the proponent to present a safety case to the Commission which explains how their operating plan and the technology that they have chosen can be made to conform to Canada's regulations. The licensing process for a commercial reactor in Canada (known in CNSC parlance as a Class I Nuclear Facility) has five components: a licence to prepare site, a licence to construct, a licence to operate, a licence to decommission, and a licence to abandon (CNSC 2008a). The utility company would need to apply for the appropriate licence at each stage of the plant's development through to the end of its life. An EA is a prerequisite for the CNSC licensing process as mandated by the *Canadian Environmental Assessment Act* (CEAA 2012). Since 2012, the CNSC is the responsible agency for carrying out federal EAs in the area of nuclear power.

The CNSC conducts public hearings at different stages throughout the licensing process to allow for public input from concerned citizens, indigenous peoples, and special interest groups. The CNSC also has a mandate to "to disseminate objective scientific, technical and regulatory information to the public" (Nuclear Safety and Control Act: Section 9b). To that effect, they engage in a variety of outreach programs which according to the CNSC are meant to "demystify nuclear science, describe our role as

[144] Marcel de Vos is a Canadian nuclear regulation professional.

Canada's nuclear regulator, and to ensure that the CNSC is known as a credible source of scientific, technical, and regulatory information" (S. Locatelli pers. comm.).[145]

Industry

In Canada the term industry can refer to utilities that operate reactors, as well as engineering firms that design and build the technology. In the case of Ontario there are only two nuclear operators: OPG and Bruce Power.

In terms of the broader industry, there are almost 200 companies involved in the construction and servicing of reactors in Canada (NRCan 2016). The industry employs roughly 30 000 people directly and generates roughly $6 billion per year in revenue (ibid).[146] All of Ontario's reactors were built by AECL in cooperation with Ontario Hydro along with a variety of smaller companies that make up the Canadian nuclear supply chain. Prior to its restructuring in 2011, AECL was not only responsible for building and marketing reactors, but also served as a key hub of nuclear R&D in Canada.

The Canadian Nuclear Association (CNA) is an industry association that lobbies the provincial and federal governments on behalf of its membership, which includes the utilities, nuclear engineering firms, and the broader supply chain. They advocate for a political and regulatory environment that promotes the well-being of the industry (CNA 2015). The Organization of Canadian Nuclear Industries (OCNI) is another industry lobby group that is active in Canada, seeking to promote the benefits of nuclear technology and advocate on behalf of its membership.

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[145] Sunni Locatelli is the Director General of the Strategic Communications Directorate at the CNSC.

[146] This figure includes revenue generated from electricity production and uranium exports.

Industry plays an important role in keeping nuclear issues on the agenda for both levels of government, throughout the course of what can be a very protracted decision-making process. Increasingly, industry seeks to prove that it can succeed independently of direct subsidy from government and compete with other low-carbon alternatives.

Academia

While academia does not play a direct role in the decision-making process, they remain a significant stakeholder within the world of nuclear power. They are a resource for industry, training the next generation of engineers and scientists, while also serving to stimulate critical research and innovation necessary to sustain and grow the industry. While at times their views may align with industry, they tend to be more forward looking, favoring innovation over the status quo. There is a close relationship between industry and academia. A great deal of research conducted in Ontario's universities is funded in part by industry to solve current problems within its aging fleet. It is also quite common for people from industry to have worked in academia and *vice versa*.

Environmental Groups

The environmental movement has a long tradition of opposing the use and continued operation nuclear power in Canada. The anti-nuclear movement has its roots in the peace movement of the 1960s (Mehta 2005). Anti-nuclear groups like the Canadian Coalition for Nuclear Responsibility (CCNR) emerged in the mid-1970s and were joined by environmental groups like Greenpeace and the Sierra Club in their opposition of commercial nuclear power. Since that time, local chapters of these larger environmental organizations along with regional groups have emerged to oppose the siting of specific projects within their communities.

Environmental groups play an active role lobbying legislators on nuclear power, while providing alternative views on the technology. They disseminate information to the public through demonstrations, traditional media, and through online forums (e.g. traditional web sites as well as social media). They raise awareness about upcoming public hearings, track media reports on nuclear issues, and work to mobilize the public and government to their cause.

They are the most vocal critics of nuclear power in Canada. They tend to be most visible at regulatory hearings as public intervenors. This is one of the few opportunities in the decision-making process for them to insert themselves. There is a broad consensus among environmental groups in Canada to oppose the continued use of nuclear power in any form.

The Public

The public is consulted during the creation of provincial policy documents like the technical plan issued by the OPA (now the IESO), as well as during the preparation of policy documents like the LTEP. Public participation is also encouraged during regulatory proceedings. The CNSC (2008) notes that public involvement can take place through comments included in the Environmental Impact Statement (EIS) or by choosing to participate in public hearings for an EA. Licensing hearings for new builds and refurbishment are also open to the public. That being said, participation in these processes can be quite low.

This section has outlined some of the key players involved in the broader decision-making process as it pertains to the construction of NPPs in Ontario. A decision regarding a nuclear reactor can always be delayed, reversed, and is rarely final. It is

instructive to look at the effort to build two new units at Darlington, a site that already hosts four units in Clarington, Ontario. In this case, the province had decided that it wanted to build two reactors for the first time in decades but ultimately failed to add any new capacity after years of development and political vetting. The province sought bids for the reactors on two separate occasions but ultimately deferred the project for an unspecified period of time in favour of refurbishing existing capacity. This next section explores how these policy decisions came about.

Darlington B (2006-2009): A False Start

As noted earlier, the province was in the process of revitalizing its nuclear program in the early 2000s. While work was underway to bring eight laid up reactors back into service, policymakers began to consider whether new capacity might be required to meet the province's growing electricity needs. In 2005 the OPA released a *Supply Mix Advice Report* at the behest of the Minister of Energy, Dwight Duncan, to provide technical advice on the province's expected electricity needs for the next 20-years. Their report recommended that nuclear power continue to provide 50 percent of the province's supply mix. At the time it was expected that 18 out of the province's 20 units would be back online by 2009. Based on the age of the fleet, the OPA suggested that there may be a need to consider new builds alongside plans for refurbishment. They contended that nuclear power could provide a more stable price over the long-term for ratepayers when compared to natural gas if "timely decisions enabled the nuclear generating options to be brought into service over a relatively short period of time" (OPA 2005: 26-27). The OPA report provided a cautious optimism that improved management

at the utilities along with new market conditions might allow nuclear power to perform better than it had in the past.

In June 2006, the province called on OPG to begin the federal regulatory process of seeking a *Licence to Prepare Site* in order to build four new units at Darlington. In March 2008, the Ministry of Energy launched the bidding process to build two new reactors.[147] Initially Bruce and Darlington were being considered as potential sites, but by June 2008, the Ministry of Energy had selected Darlington as the site for the new build. They were seeking 2000MW of new capacity (Bratt 2012).[148] OPG, a wholly-owned provincial utility, would be its owner and operator. The province was publicly committed to investing $40 billion into its nuclear fleet, which included a refurbishment of the existing units and two new reactors at Darlington (Cadham 2009).[149] The plan called for the two new reactors at Darlington to be completed by 2018.

The province wanted to avoid making the mistakes of the past when it came to cost overruns on new capacity. To that effect, they made the bid a competitive process that was open to foreign manufacturers. This would be the first time that AECL would need to compete against global players like Westinghouse and Areva at home. In addition to making it a competitive process, the bid also sought to have the vendor be responsible for the financial risks associated with cost overruns (Bratt 2012). This requirement would force engineering firms to build into their proposal an adequate contingency fund to

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[147] The plan was to add two more units to the proposed Darlington B at a later date.
[148] Both Bruce and OPG had submitted applications to the CNSC, but the province had determined Darlington to be the preferred site. Bruce Power later withdrew their application.
[149] The plan was for Ontario to maintain 14 000MW of nuclear capacity or roughly 50 percent of the supply mix. This target was formalized in the 2007 Integrated Power System Plan (OPA 2007).

cover potential cost overruns. These requirements were seen as a concerted effort on the part of the Government of Ontario to get a better price for the ratepayer. The bid was supposed to be technology neutral and assessed principally on the actual cost of the reactors. The bid also included a provision that took into consideration the economic benefits the province might gain from a particular proposal (ibid.).[150] The bidding process was open from March 2008 until February 2009.

At the time AECL was proposing a new reactor, the Advanced CANDU reactor (ACR-1000), a 1200 MWe design; their first foray into designing and building a Generation III+ design.[151] AECL needed to build a reference plant in Ontario to facilitate the export of this new design and restore confidence in their brand. In partnership with AECL, the ACR-1000 was being advanced by a team of engineering and construction firms that included GE-Hitachi Canada, Babcock & Wilcox Canada, and SNC-Lavalin Nuclear (Cadham 2009).[152] The ACR-1000 would have to compete with Areva's 1650 MWe EPR and Toshiba-Westinghouse's AP 1000, two Generation III+ designs with reference plants already under construction, and with export financing available from their home states (Tammemagi and Jackson 2009). AECL could not get federally-backed export loans for a sale at home putting their team at a significant disadvantage in this

[150] Bratt (2012) notes that 80 percent of the evaluation was based on the cost and readiness of the project, with the remaining 20 percent being assessed based on the contribution to the province's economy.

[151] The ACR-1000 was a hybrid between a CANDU design and a PWR. It used low-enriched uranium for fuel, light water as a coolant, and heavy water as a moderator (Candu 2011). The design changes were meant to reduce the amount of heavy water needed to operate the plant, helping to greatly reduce its O&M costs (Tammemagi and Jackson 2009).

[152] GE-Hitachi had been invited by the province to participate as a vendor in its own right, but opted to take part as a member of Team Candu along with AECL supporting the ACR-1000 design (Cadham 2009).

regard (Cadham 2009; Bratt 2012). To further strengthen their bids, Areva and Westinghouse made commitments to use Canadian labour and components where possible. Areva had made the case that it would use Canadian content for up to 70 percent of the proposed EPR at Darlington if they were selected (Cadham 2009).

George Smitherman, the former Minister of Energy and Infrastructure, contends that these possibilities never had to be seriously considered by the province. He argues that "Areva never forced that question" because ultimately neither they nor Westinghouse were compliant with the province's Request for Proposals (RFP) (G. Smitherman pers. comm.). On June 29, 2009 Smitherman announced that the bid had been suspended by the province. While unwilling to disclose precise figures, Smitherman said that they were "billions" more than what had been expected by the province (quoted in Hamilton 2009b). While it was acknowledged that AECL had provided a compliant bid, it was still far more than what the Province had been prepared to spend.

The structure of Ontario's RFP ultimately drove up the cost of the proposals and led to very little competition amongst the qualified bidders. "There were not many people too interested to sign on to the all-risk take back model…so what we had was a proposal for new nuclear construction [from AECL] that was well beyond our price/risk appetite" (Smitherman, pers. comm.). The Province had hoped that a competitive bid would serve to drive down the price of a reactor from AECL and entice the Federal Government to financially support the project, but their plan failed on both counts.[153]

[153] If the other bids had been compliant with the Province's RFP, there would have been other obstacles to comparing the different designs. Jeremy Whitlock, a longtime AECL/CNL employee suggests that different plant infrastructure, and vendor accounting practices would have made a straight comparison difficult based on price alone. "It wasn't apples to oranges and this was part of the reason why the bid went back and had to

While AECL had submitted a bid that met the requirements of Ontario's RFP, there were still a number of challenges aside from price that would force the province to reevaluate their plans. Three factors that served to stall the bid included: price, federal/provincial disagreements over who would bear the risk associated with cost-overruns, and the uncertainty generated by AECL restructuring.

The Federal-Provincial Tango: Who Pays?

While the details of the bid were never formally released, a Toronto Star article reported that the proposed ACR-1000s were going to cost the province $26 billion for two units or 10 8000/KW (Hamilton 2009b).[154] This was more than three times the price anticipated by the OPA in their 20-year energy plan. John Cadham (2009) suggests that part of the inflated price tag for the ACR-1000 was driven by the Province's demand for an all-in-price that would shoulder the risks associated with potential cost overruns. By 2009, the Federal Government had no appetite to take on the risk associated with a new build given their plans to exit the nuclear business. Federal funding for AECL had traditionally been premised on the idea that it would lead to lucrative exports down the road (Bratt 2006). After years of failing to deliver on this promise, Stephen Harper's Conservative Government was more inclined to let the market determine what would be competitive. This meant that AECL would have to recover its R&D costs from the sale of two units to Ontario (Cadham 2009). This was an extremely tall order for AECL. Keep in

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be revised…you have to compare radically different designs with a totally different architecture" (J. Whitlock pers. comm.). Whitlock contends that had the bids been properly dissected, that AECL could have at the very least been able to match a competitor's price.

[154] Areva by contrast reportedly offered two 1600MWe EPRs at $23.6 billion, or $7375/KW.

mind that this was a company that had not sold a reactor in over a decade and had not built a reactor in Canada since it completed the first Darlington plant in 1993. By contrast, their competitors were actively building reference plants around the world, allowing them to gain experience, and at least in theory bring down their costs. They also benefitted from strong financial support from their home governments. Without financial assistance from the Federal Government, Ontario would be forced to pay a substantive premium in order to purchase a Canadian design.[155]

According to Smitherman, there did not seem to be any indication that the Federal Government wanted to make a deal happen. He suggests "that they had largely decided that they were getting out of this business, so this idea of subsidy, or better said risk underwriting and the like on the part of the National Government, best as I can recall was not in play" (Smitherman pers. comm.). The Federal Government for its part felt that they had already made a significant contribution to the project. Ottawa had invested a total of $225 million into the development of the ACR-1000 from 2009 to 2011 (Weston 2011).

[155] The all-in-price includes more than simply two reactors. It also would have included the cradle-to-crave costs associated with the plant plus a contingency fund for overruns during construction. These added costs include things like: infrastructure required during construction (e.g. a new highway overpass), upgraded transmission and distribution systems, 60 years of fuel, as well as decommissioning costs (Bratt 2012; Hamilton 2009b). There would be additional risks given that Darlington would serve as the reference plant for the ACR-1000 design. Someone who had worked on the ACR-1000 design asserted that there is always a high degree of concern and trepidation when undertaking such a project. Even with years of modelling and design work, new designs like the ACR-1000 will still have problems that need to be worked out in the reference plant. "There will always be issues with it. It will never be a perfect build. There is always the risk of schedule delays, cost overruns, and unforeseen technical aspects that may be lurking there" (Anonymous pers. comm.). These problems face all FOAK designs and are not unique to the ACR-1000. The problem for AECL was that no one was willing to underwrite the costs associated with those risks.

They were not interested in providing additional subsidies to AECL or the province of Ontario to support this project.

In the background to these negotiations, the Federal Government was in the process of trying to privatize the AECL Reactor Division. When it suspended the bid in June 2009, the province cited this as a concern. Any decision to sell off AECL's Reactor Division in the midst of negotiations would have serious repercussions. AECL and Ontario seemed to believe that this failed bid was the first step in future negotiations, but there was too much uncertainty to move ahead at that time.

Restructuring AECL

Crown Corporations blend government-owned enterprise with private-sector operations. Ideally they are self-sustaining businesses that can turn a profit for the government, but in practice they have often required large amounts of funding in the form of parliamentary appropriations to stay afloat (Crisan and McKenzie 2013). In 2010 AECL was seen as one of the worst performing crown corporations in Canada (ibid.). Its business had been hurt by languishing domestic and international sales of its CANDU reactors, along with a series of scandals surrounding medical isotope production. AECL was seen as a financial liability for the Conservative Government eager to cut their losses with this struggling crown corporation. AECL was reported to have lost $300 million in 2009-2010 alone (Office of the Parliamentary Budget Officer 2013). This was particularly troubling given the level of investment AECL had received from the Federal Government in the lead up to the privatization of its reactor division; approximately $2 billion over a three-year period (Boardman and Vining 2012).

In 2007 the Federal Government undertook a two-year review to find ways to make the crown corporation more competitive. Amidst talk of a global nuclear renaissance they wanted to position AECL to succeed. On May 28, 2009 following a two-year review, Lisa Raitt, then Minister of Natural Resources Canada, announced the government's decision to go ahead with the restructuring of the AECL. It was seen as a way "to leverage Canada's long-term investment in nuclear energy and strengthen Canada's nuclear industry at a time of global expansion" (NRCan 2009). AECL's assets would be partitioned in order to make it attractive to a potential bidder. The CANDU Reactor Division would be sold separately from the Research and Technology Division in the first phase of the restructuring of AECL.[156]

The sale of AECL's Reactor Division would ultimately take two years to complete, a period in which the crown corporation put much of its business on hold, leaving Ontario uncertain as to when it would be able to negotiate a final deal on the Darlington new build (Dubinsky 2011). Michael Ivanco, then Vice President of the Society of Professional Engineers and Associates (SPEA), argued that the 21-month restructuring period "prevented [AECL] from signing any large lucrative contracts to keep its engineers working" (quoted in "Safety before Expediency" SPEA 2011). While the Federal Government for its part rejected the idea that there was an express limit on

[156] The Research and Technology Division became Canadian Nuclear Laboratories (CNL) on November 3, 2014 as part of the second phase of the AECL restructuring process. A private consortium called the Canadian National Energy Alliance (CNEA) took control of CNL in 2015 as part of a Government-owned, Contractor-operated (GoCo) model. CNL is now for all intents and purposes a private sector actor. AECL continues to exist as a much smaller crown corporation, whose primary function is to manage the GoCo contract. AECL remains responsible for federal liabilities related to its historical activities. They are also the federal entity that provides funding for federal R&D, waste management, and decommissioning at CNL sites.

the type of business AECL could conduct at the time, business was by and large put on hold in Argentina and Ontario (Dubinsky 2011).[157]

Premier Dalton McGuinty and the Ontario Liberal Government for their part remained committed to getting a deal done, but one where the price made sense for the province. The Ontario Premier wanted a deal done ahead of the restructuring process. He believed that this was mutually beneficial to the province as well as any potential buyer of AECL:

> We're at a table, and we want to negotiate the sale of reactors with AECL […] Well, there's nobody sitting on that side of the table, because they're elsewhere trying to make a sale of the entire asset itself to some third parties […] As long as they do that, they're putting our discussion in abeyance (quoted in CP 2011b).

Even after the announced sale of the reactor division to SNC-Lavalin on June 29, 2011, the McGuinty Government continued to press for support from the Federal Government on the Darlington project, likening it to the loan guarantees provided to Newfoundland and Labrador for the Lower Churchill Hydro Project (McCarthy and Howlett 2011).

The Conservative Government had begun the restructuring process in part to avoid being on the hook for these kinds of liabilities for future projects.[158] AECL had come to represent a costly liability for the Federal Government, one that incentivized

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[157] The Federal Government had placed a great deal of financial and human resources into getting the restructuring process completed in a timely manner. This consumed most if not all of its policymaking capacity at this time, limiting the Federal Government's ability to address other pressing strategic policy concerns in the area of nuclear power (Anonymous pers. comm.). The prolonged and staged AECL restructuring process cluttered the federal policy space in unhelpful ways and created a great deal of uncertainty for would-be buyers.

[158] The Government of Canada remained responsible for refurbishment projects already underway at Point Lepreau and Bruce, both of which were incurring large cost-overruns of $1 billion and $2 billion respectively ("AECL Sold for $15M to SNC-Lavalin" CBC 2011). Candu Energy, a subsidiary of SNC-Lavalin, would complete the other planned refurbishments in Quebec and South Korea as a subcontractor to AECL.

getting the restructuring process done as quickly as possible. In practice, this meant that there was little appetite on the part of the Federal Government for getting involved in another multi-billion-dollar project like Darlington. This put any deal with Ontario on hold to allow SNC-Lavalin to assess the business case for the project on its own merits. To that effect, the 2011 deal with SNC-Lavalin to purchase the reactor division from AECL did not commit the Federal Government to support any future sale of reactors to the Province of Ontario (McCarthy and Howlett 2011).

Talks Resume: New Builds Reconsidered (2011-2013)

While talks surrounding the Darlington new build had largely stalled from 2009 to 2011, the province remained interested in the technology. The impending phase out of coal-generated electricity put pressure on the Ontario Government to seek alternative sources of baseload generation. During the initial bid period (March 2008 to June 2009) there had been some internal disagreements as to whether Team Candu (the AECL-led team) should promote the next-generation ACR-1000, or the Enhanced-Candu-6 (EC6), a more modest evolution of the existing design already operating within the province (Bratt 2012). Those endorsing the EC6 at the time argued that it was a proven design, that was shovel ready, and more likely to be built on time and budget (Hamilton 2009a).

Following the sale of the AECL Reactor Division to SNC-Lavalin in 2011, it became clear that the EC6 would be the reactor that would be promoted in lieu of the ACR-1000. Part of the sale of AECL had included a clause that committed Ottawa to spending up to $75 million to complete the EC6 design (CP 2011a). This would be crucial to ensuring that the design was market ready should Ontario or an export market decide to go ahead with a new build. One interviewee noted that, while on paper there

were many benefits to adopting the ACR-1000, SNC-Lavalin was more conservative in its approach to new builds. They viewed the untested ACR-1000 as a "hard sell" (Anonymous pers. comm.).[159] By 2012, the Ontario Government had also come to favour the EC6 from SNC-Lavalin's subsidiary, Candu Energy.[160]

By June 2012 Ontario had resumed talks with Westinghouse and Candu Energy on the possibility of new builds at Darlington. They signed service level agreements which called on the two the vendors to produce "detailed construction plans, schedules and cost estimates" for the EC6 and the AP 1000 at Darlington (WNA 2017f). The two AP 1000 units were expected to cost $10.4 billion, while the EC6 units were expected to cost between $10 to $14 billion or $5000-$7000/KW (Spears 2012). Formal plans were submitted in June 2013, but stalled for a second time only six months later.

Plans Subject to Change: LTEP 2013

The December release of the 2013 LTEP put plans for a nuclear new build at Darlington on hold yet again. The 2013 LTEP was a policy document released by the Ministry of Energy meant to outline a 20-year plan for Ontario's supply mix. The document was produced independently of the technical plan released by the OPA. It served as an update to the 2010 LTEP, the first of its kind in the province (MOE 2010; MOE 2013). The update decreased forecasted growth in electricity demand by 16 percent for 2032 as a result of conservation efforts in the province, eliminating the anticipated

[159] Candu Energy is no longer actively marketing the ACR-1000. It has been suggested that the design was "a little bit too revolutionary" with too many lingering technical issues to resolve and no markets interested in taking on the risk (Anonymous pers. comm.).

[160] SNC-Lavalin created a wholly-owned subsidiary called Candu Energy to operate the reactor division that it purchased from AECL.

need for new nuclear generation in Ontario (MOE 2013: 4). This was a relatively significant departure from the 2010 LTEP, which had anticipated a 15 percent growth in electricity demand from 2010 to 2030 (MOE 2010).

Energy consumption was down in all major industrial sectors following the 2008/2009 recession, with a slower recovery than what had been anticipated by the province.[161] The 2013 LTEP asserted that while electricity demand was likely to remain flat for the next ten years, this did not mean that economic growth had stagnated. For its part, the Ministry wanted to suggest that a leaner Ontario economy would prosper and save money, all while reducing its electricity consumption. "The future promises to be less energy-intensive than the past because demand for energy is no longer as closely linked to economic growth…" thanks to improved efficiency and conservation efforts across the province (MOE 2013: 11). This rosy outlook allowed provincial policymakers to present a negative forecast as a net positive for the ratepayer. Postponing plans for new builds at Darlington would save the province up to $15 billion in capital investments and would serve to keep electricity costs down for the ratepayer (MOE 2013). The LTEP noted that the province could revisit the question of additional nuclear capacity at Darlington "should the supply and demand picture in the province change over time" (MOE 2013: 29). To maintain this flexibility, the province would work with OPG to maintain the 10-year *Licence to Prepare Site* granted by the CNSC for the Darlington new builds. With plans for a revised LTEP to be released every three years, there would

[161] The 2013 LTEP noted that electricity consumption was down amongst Ontario's five largest industries. From 2005 to 2012, it had decreased by 5.5 million kWh (MOE 2013: 11). This decrease is comparable to the annual output of a CANDU reactor.

be ample time to see whether demand forecasts could justify new construction down the road.

The 2013 LTEP remained committed to the planned refurbishment of 8500MW of capacity at Darlington and Bruce beginning in 2016, with Pickering units remaining in operation until 2020.[162] The risks associated with refurbishment would be mitigated "by establishing appropriate off-ramps" to protect the ratepayer should the projects fail to adhere to budget and/or schedule (MOE 2013: 29). The Ministry of Energy has warned the industry that if the refurbishment process becomes too costly or takes too long to achieve then they might be forced revise their plans. The idea of "off-ramps" being potentially used to limit the number of units refurbished is in line with the LTEP's overarching goal of being both flexible and pragmatic in its plan to maintain an electricity supply that is cost-effective, reliable, and clean.

Whether the LTEP achieves what it claims to do is a different story. There is evidence to suggest that the province's electricity planning over the last decade is in some disarray given the poor coordination between the Ministry, the OPA/IESO, and the OEB. In a scathing report from the Auditor General of Ontario (2015: 213), Bonnie Lysyk chastised the Ministry of Energy for "operating outside the checks and balances of the legislated planning process…[resulting] in significant costs to electricity consumers." The next section explores some of the consequences of this decision-making process and what it has meant for Ontario's supply mix.

[162] This plan was revised by the Ministry of Energy in 2016. The Pickering plant is now expected to operate until 2024 (MOE 2016).

Ontario's Electricity Planning: A Top-Down Approach?

Decisions regarding Ontario's electricity supply mix are supposed to be informed by a technical plan that ensures that the Province can meet its energy needs in a reliable and cost-effective fashion. Based on the *Electricity Act, 1998*, this process is supposed to be driven by the OPA (now part of the IESO as of January 1, 2015). The OPA was designed to act as an independent source of technical expertise, used to conduct medium and long-term forecasting, for Ontario's electricity generation system (Ontario Legislative Assembly 2004). One of its key functions would be to create a technical 20-year planning document known as the Integrated Power System Plan (IPSP). The IPSP was meant to inform the Province of what it needed to acquire in order to maintain an appropriate supply mix (ibid.). The plan would be vetted by the OEB[163] to ensure that it provided good value for the ratepayer and was in line with the government's supply mix directives before ultimately being approved by the Ministry of Energy (Office of the Auditor General of Ontario 2015). In practice, the IPSP has been largely ignored by the Ministry of Energy who has instead opted to manage the supply mix as it sees fit. This top-down approach to electricity planning has done little in the way of promoting the policy objectives of a cost-effective, reliable, and clean supply mix for Ontario.

The OPA created two technical plans: one in 2007 and an updated one at the behest of the Ministry of Energy in 2011. The Ministry of Energy has failed to adopt either plan. The Ministry has displaced the OPA's technical plan, the IPSP, in favour of their policy-oriented LTEP, not subject to OEB oversight. The Ministry has argued that

[163] The OEB is the provincial regulator; they are responsible for setting transmission and distribution rates.

"the technical plan was no longer warranted following the release of its 2013 policy plan [the LTEP], noting that the technical-planning process is expensive, lengthy, and inflexible for responding to market changes" (Office of the Auditor General of Ontario 2015: 217). By contrast, the LTEP has been criticized for usurping the role of the IPSP without a legislative mandate to do so. More troubling to its critics has been its limited transparency, poor stakeholder engagement, and the limited cost/benefit analysis for the projects it endorses (Office of the Auditor General of Ontario 2015).

This top-down approach to electricity planning has led to a costly oversupply of generating capacity in the Province of Ontario. In a period where demand has declined, supply has increased well beyond the needs of the Province, leading to increased costs for the ratepayer.[164] From 2004 to 2014 ratepayers saw an 80 percent increase in their electricity bill, with rates increasing from an average of 5.02 cents/kWh to 9.06cents/kWh (ibid.). Long-term supply contracts have played a role in driving up costs for the ratepayer. They provide generators a guaranteed price for the electricity they produce over the duration of their contract. Roughly 65 percent of the province's generating capacity is now under contract with the IESO (ibid.). These contracts are meant to incentivize investment in certain kinds of power generation like renewable and nuclear energy. Ratepayers ultimately pay the difference between the guaranteed price and the hourly market rate through a mechanism known as the global adjustment fee that appears on their hydro bill. The structure of these long-term contracts means that even when generators are forced to limit their production by the IESO as a result of a glut,

[164] At present the Ontario AG (2015: 215) notes that the province produces on average 5160MW per year more than required. This is roughly the same output as all of Manitoba.

Ontario generators are still paid in full. Ratepayers also cover losses on exports, when excess power is sold to the US or neighboring provinces at rates well below the price guaranteed to them by IESO. Exports from 2009 to 2014 cost the province $32.6 million, while $339 million was spent curtailing supply during that same period (ibid.). Long-term contracts signed between generators and the IESO are exempt from OEB oversight.

Much of the excess supply in the Province has been driven by green initiatives meant to attract investment in renewable technologies.[165] The guaranteed prices they offered for renewable sources of electricity encouraged far more investment than they could effectively manage. "The Ministry's attractive guaranteed prices program has been one of the main contributors to the surplus power situation Ontario has faced since 2009, in that it has procured too many renewable projects, too quickly, and at too high of cost" (Office of the Auditor General of Ontario 2015: 226). Lysyk estimates that the Province overpaid for wind and solar projects by as much as $9.2 billion from 2009 to 2013. Lysyk asserts that the Ministry of Energy did not seem to fully appreciate how the rapid adoption of renewables would work with its existing supply mix that relied principally on hydro and nuclear power generation. The high costs associated with curtailments and exports of excess hydro and nuclear do not seem to have been seriously considered by the Ministry of Energy.

Jatin Nathwani (2015) has been critical of the AG's analysis. He claims that it overlooks the benefits that these initiatives have provided the Province. As a result of investing $30 billion in its electricity sector, the Province has created 250 000 new jobs,

[165] Many of these initiatives including Ontario's feed-in-tariff are laid out in the *Green Energy and Green Economy Act, 2009* (now known as the Green Energy Act).

added 13 000 MW of low carbon capacity, and phased out the use of coal in its supply mix. Nathwani makes the case that the current surplus leaves Ontario well positioned to help Canada meet its emissions targets, and could prove beneficial as the country transitions to a green economy. The Minister of Energy at the time, Bob Chiarelli, echoed these sentiments, asserting that the Province's energy policy is "ahead of the wave" and "the word 'overpaying' doesn't even enter into the equation" (quoted in Ferguson and Benzie 2015). Neither Nathwani nor Chiarelli seem to refute the argument that the Ministry has circumvented the checks and balances built into the electricity planning system provided by the OPA and the OEB. In fact, the Ministry of Energy has accepted all of the recommendations made in the AG report and has made clear that changes to existing legislation are already underway.

The Ontario Liberals have begun the process of amending the *Electricity Act* to reflect their preference for the policy-oriented LTEP though *Bill 135 Energy Statute Law Amendment Act, 2016*.[166] In essence, Bill 135 formalizes the role of the LTEP within the legislative framework as the guiding policy document ultimately responsible for long-term electricity planning. According to critics of Bill 135, it erodes the independence of the IESO and the OEB, removing the last vestiges of independent planning. The bill declaws the independent checks and balances on the electricity planning process and turns them into tools for the implementation of the Ministry's policies and directives (Vegh 2015). The Ministry has defended the amendment, asserting that it provides further

[166] The bill also amends the *Green Energy Act, 2009*, and the *Ontario Energy Board Act, 1998*. It received Royal Assent on June 9, 2016. For a full text of the amendment see: (Ontario Legislative Assembly 2016).

clarity to the role of the IESO by ensuring that their technical expertise is properly consulted in preparation for the next LTEP.

In addition to an increasingly centralized and top-down approach to electricity planning, the Ministry has been criticized for its poor stakeholder engagement. While public consultations were held for the 2010 and 2013 LTEP, serious doubts were raised as to how their contributions were incorporated into the policy documents. The 2013 LTEP was released less than a week after its public consultation period had ended, calling into question whether those responses were actually evaluated and incorporated into the document (Office of the Auditor General of Ontario 2015). The Ministry of Energy asserts that this shortcoming will be rectified by the protocols that it has introduced for the enhanced LTEP in Bill 135. They have said that it will include: "extensive consultations with consumers, stakeholders, and aboriginal groups, and the creation of the plan will be consistent with the principles of cost-effectiveness, reliability, clean energy, community, and aboriginal engagement" (Office of the Auditor General of Ontario 2015: 220). The effectiveness of this improved consultation process remains to be seen.

This brief discussion of the Ministry of Energy's management of this process is meant to highlight how technocratic decisions are increasingly politicized, with limited input from experts or the broader public. Given the rapid growth of renewables in Ontario in conjunction with the Ministry of Energy's current forecast for electricity demand, these policy decisions have likely served to further dampen any need for new nuclear capacity in the province for the foreseeable future.

What we have seen in the preceding sections is a decision-making process largely driven by the Province, the Federal Government, and industry. Environmental groups and the public are by and large absent from the discussion. The next section returns to the case of Darlington and explores their role in this process.

Environmental Groups and the Public: The Darlington Judicial Review of the EA

Environmental groups and concerned citizens tend to be appear much later in the decision-making process, long after a proposal has been promoted by industry and vetted by policymakers. They tend to be most visible at regulatory hearings and public consultations. While often dismissed by industry as being unreflective of the broader public, environmental groups are a stakeholder that can be seen as a challenger to the status quo.

Environmental groups have been most effective at influencing the process through EAs, where public consultation is a legal requirement. The EA is part of the decision-making process used to evaluate potential environmental risks associated with a project and is meant to "minimize or avoid adverse environmental effects before they occur; and incorporate environmental factors into decision making" (CEAA 2015c). Environmental groups enter the process as intervenors. Public funding is made available to intervenors to be able to attend these hearings to ensure that a wider segment of the population is consulted during the regulatory process (S. Locatelli pers. comm.; CEAA 2015a). This funding can in some cases be critical to keeping these groups engaged. Michael Mehta (2005) notes that smaller anti-nuclear groups often disband or go on hiatus when they run out of intervenor funding.

In the case of Darlington, a Joint Review Panel (JRP) had been established to conduct the EA for the proposed new builds. The hearings were held from March 21, 2011 to April 8, 2011. From the outset, environmental groups raised concerns about whether it was appropriate to be holding the hearings so soon after Fukushima, without time to properly assess the implications of the accident for the Canadian nuclear industry (Joint Review Panel 2011).[167] During the hearings environmental groups raised concerns over how reactor designs were being assessed. They asked about the preparedness of OPG for Fukushima-like accidents, the potential for radioactive releases into the Great Lakes, the dangers posed by terrorist attacks on the facility, and the overall procedural fairness of the review itself (ibid.). In spite of these and other concerns raised by environmental groups the JRP granted OPG an EA for its proposed new builds on August 25, 2011.

Environmental groups were unsatisfied with the outcome of the EA process and sought to have it challenged. They included: Greenpeace Canada, Lake Ontario Waterkeeper, Northwatch, and the Canadian Environmental Law Association. The 2011 EA granted by the JRP had allowed OPG to apply for and receive a *Licence to Prepare Site* by the CSNC in 2012. This was the first step in a federal licensing process that would potentially allow OPG to proceed with the project at a later date should they so choose.[168] Even though there had been a political decision to defer the Darlington project indefinitely, the 2013 LTEP made clear that the Ministry of Energy would work with

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[167] On March 22, 2011 Greenpeace Canada disrupted the proceedings with a protest. They were frustrated by the JRP's decision to continue with the proceedings rather than postpone the hearing following the Fukushima accident (Joint Review Panel 2011).
[168] If maintained the licence is valid for 10 years. For a complete timeline of their licensing application, see: (CNSC 2016c).

OPG to maintain the licence from the CNSC to allow for this decision to be revisited at a later date. The judicial review initiated by Greenpeace et al. could serve to eliminate that option altogether.

Environmental groups launched a process known as judicial review to challenge the EA granted by the JRP. Greenpeace et al. raised concerns regarding the potential release of hazardous substances, severe accidents, and the long-term management of high-level waste produced by the proposed reactors (King et al. 2014). They also took issue with the methodology used to conduct the EA which allowed for the reactor design to be selected at a later date. Greenpeace et al. asserted that this left too much of the project undefined, making it impossible for the application to meet the criteria set out by the *Canadian Environmental Assessment Act* (CEAA) 1992 (King et al. 2014).

They asserted that "the use of the bounding approach, and the failure to assess a specific reactor technology, undermined the Panel's ability to properly evaluate the Project's environmental effects" (Greenpeace Canada v. Attorney General, Federal Court 2014: 33). The bounding approach "consider[s] the greatest adverse impact to the environment," given the range of technologies under review (King et al. 2014). It was meant to provide OPG the flexibility necessary to make a decision on a reactor vendor and design at a later date without having to restart the process. The designs being considered by the JRP were based on the Environmental Impact Statement (EIS) submitted by OPG in September 2009. They included the AP-1000, the EPR, and the ACR-1000. The EC6 was added as an additional option in July 2010 (Greenpeace Canada v. Attorney General, Federal Court 2014).

The judge ruled that while the bounding approach itself was not problematic, the EA had failed to consider in sufficient detail the dangers posed by hazardous substance releases, the issue of long-term waste management, and the potential for severe accidents on site (King et al. 2014). The judicial review sent the EA back to the JRP for these issues to be reexamined and addressed rather than invalidating their entire report. The ruling in practice revoked the *Licence to Prepare Site* granted by the CNSC. The licence could not be reissued until the JRP resolved the lingering issues with the EA.

While this ruling was ultimately overturned by the Federal Court of Appeal in 2015 (Killoran et al. 2015), it provides an interesting case where environmental groups were able to successfully bring their concerns to the fore, and effectively (albeit temporarily) challenge industry practices when it came to nuclear power. Environmental groups have been raising issues like these for years in the fight to get Ontario to abandon nuclear power (Mehta 2005). While unsuccessful in their bid to stop the licensing of the Darlington site, this case should serve as a wakeup call to industry that environmental groups are becoming increasingly sophisticated in the way in which they approach regulatory hearings and the EA process. Perhaps not surprisingly, environmental groups remain deeply skeptical of a regulatory system that they view as unfair and rigged in favour of industry.

A Rigged System?

In speaking to environmental groups that have participated in these hearings, they expressed a deep frustration with the whole process. John Bennett, the former Executive Director of the Sierra Club Canada Foundation noted that while they are often given the opportunity participate, their views are not always taken seriously. “In these hearings, we

are allowed to talk but we are not listened to" (J. Bennett pers. comm.). Bennett felt that the CNSC, the federal nuclear regulator, was biased in favour of the industry. This bias, according to Bennett, does not allow a project to be assessed in a truly impartial fashion. He asserts that there is too close of a relationship between the industry and the regulator. This is a position echoed by other environmental groups like Greenpeace Canada that feel the CNSC has become a cheerleader for industry and is failing to maintain the proper distance appropriate for an independent regulator (Stensil 2015; Hamilton 2012).[169]

Groups like Sierra Club Canada claim that the regulator is not doing its job when it comes to keeping Canadians safe from the dangers posed by nuclear power. One example they regularly cite is the high levels of tritium being released by CANDU reactors into the drinking water and the failure of the CNSC and industry to protect Canadians from this "known carcinogen" that is dangerous to human health (Sierra Club Canada 2011: 4). Within this narrative, the CNSC is viewed as an adversary, along with industry for its failure to protect Canadians from the unacceptable risks posed by the ongoing use of nuclear power. For groups like these, "there is no justification to accept either the expense or the risks of nuclear technology" (Sierra Club Canada 2011: 1). The CNSC is seen as complicit in accepting the status quo by continuing to allow the industry to operate within Canada.

The CNSC Responds to its Critics

The CNSC has responded to attacks made by environmental groups, defending their record quite vigorously. They want to make clear to the public that the industry is

[169] It is worth noting that similar complaints had been lodged against past CNSC presidents by environmental groups (Bratt 2012).

being properly regulated, and that nuclear power generation is a safe form of "low-emission electricity" (Hamilton 2012).[170] In addition to licensing, the CSNC is responsible for being a reliable source of "objective scientific, technical and regulatory information to the public" on all things nuclear (CNSC 2014b). For example, the CNSC regularly publishes reports on subjects of public concern like tritium releases to provide objective and science-based discussions on these kinds of emissions and the health risks that they pose (CNSC 2008b).

This makes it of critical importance that they be able to effectively respond to their critics and not allow them to gain credibility amongst the Canadian public. This is at times made difficult by their opponents who use information not necessarily based on sound science to criticize their work. The regulator must sort through the submissions provided to them and "be able to provide clarifications on the validity of some of the conclusions that they [environmental groups] are making" while still responding to the "valid issues" that they raise (J. LeClair pers. comm.). The challenge for the regulator becomes sorting out legitimate concerns from those that are ideologically driven.

On April 28, 2016, the Supreme Court of Canada declined to hear an appeal filed by Greenpeace et al. regarding the Darlington EA. In response to this news, the CNSC issued the following statement on their website: "The final result in this case is a validation of the Canadian Nuclear Safety Commission's competence as an expert

[170] Michael Binder President of the CNSC has gone on the record criticizing environmental groups who use "so-called scientific observations [to argue] that everything we do is unsafe" (quoted in Hamilton 2012). This was in response to the Sierra Club releasing a report on the dangers posed by tritium. Binder made the case that their 63 years of safe operations underscored the effectiveness of the CNSC as a national regulator.

nuclear regulator that conducts proper and legal environmental assessments, and ensures the safety of the public and the environment" (CNSC 2016b). This statement reflects just how damaging the judicial review could have been had the 2014 ruling from the Federal Court been upheld. The CNSC now finds itself on firmer ground to be able to defend itself and its mandate as the federal regulator.

These kinds of disputes matter because they highlight the challenges nuclear technology faces in Canada when seeking broader social acceptance. The regulator and industry regularly demand a discussion based on objectivity, science, and a technical understanding of safety. Environmental groups by contrast, while at times forced to speak in those terms, want a values-based discussion that asks whether nuclear power is morally and ethically acceptable. Regulatory proceedings and public hearings tend to be project specific, but anti-nuclear intervenors are often trying to broaden the discussion to ask whether nuclear power as a technology is acceptable to Canadians. The problem for these hearings is that they are not designed to accommodate questions of social acceptance and social licence. They are designed to assess from a technical point-of-view whether the proposed activity is safe, and whether the licensee/applicant (the utility in most cases) is capable of carrying out the requirements of the licence.[171] To that effect the CNSC has had to be quite explicit in defining its mandate. They maintain that social acceptability is not part of their decision-making criteria when determining whether or not to issue a licence:

[171] The CNSC is not licensing a specific technology (e.g. a reactor design). Instead the CNSC licensing process is meant to licence a specific activity. A utility wanting to operate a reactor must prove to the Commission that they have the planning and competence to needed to operate that plant safely (de Vos pers. comm.).

> [It] is not part of our mandate that is not part of our process. Our decisions are made on whether the activities are safe. So we need to assure ourselves that the applicant, the licensee is qualified and will make adequate provisions for the protection of health, safety, and the environment. And that is the basis of our reviews and that is the basis of our recommendations and that is the basis of the commission's decision. So, social acceptability is not part of the ultimate, the final, decision of the Commission (LeClair pers. comm.).

This is an ongoing challenge for an industry perceived to be dangerous to human health and safety by some segments of the Canadian public. Regulatory hearings are one of the few opportunities for public consultation. They may not be the place where the policy decision to initiate a specific project is made but they can prevent it from going forward. Regulatory hearings are perceived as one of the only official forums where concerns over social acceptability can be injected into the decision-making process regarding a project like a new build or a refurbishment. And yet the CNSC remains adamant that this is not the appropriate place to discuss these matters. From the Regulator's point-of-view, it is the role of industry to conduct adequate stakeholder engagement to ensure that the local community is properly informed of the benefits of a particular project and willing to host it (LeClair pers. comm.).[172] For the CNSC, these matters should already have been resolved with the host community so that the regulatory hearings can focus on the technical merits of a project and the competence of the applicant when deciding to licence a specific project/activity. This begs the question: where ought a discussion on the social acceptability of nuclear power take place?

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[172] This position has been reiterated by the CNSC Commission Secretary Marc Leblanc (2016). In a presentation delivered to the Ontario Power Summit, he asserted that: "The CNSC cannot be expected to reject a safe project due to lack of social acceptability." On his presentation slides he notes that "social acceptability is not part of our mandate" (Leblanc 2016).

The Industry's Approach to Communication and Criticism

This was a regular point of discussion not only in the interviews that I conducted, but also at the industry conferences that I attended. The Canadian nuclear industry is well aware of the challenges of communicating effectively with the public and the challenges of securing and maintaining a sufficient degree of social licence needed to operate in Canada. There was an acknowledgement from various stakeholders interviewed that while local communities at Ontario's NPP sites (Pickering, Darlington, and Bruce) are supportive of their plants, and the benefits that they bring to the community, that the broader public is not really aware of what they do or the extent to which the province uses nuclear power. Justin Hannah of Candu Energy acknowledged that "the general public is aware notionally, and they are a bit ambivalent, they are in what I would call a kind of default endorsement of keeping nuclear power plants running, [but] building new power plants is associated with risk and security and safety" (pers. comm.). He went on to note that the support nuclear power receives, "while moderately good is very fragile and the anti-nuclear movement is very good at shaking that fragility" (ibid.).

While the regulator might count on the industry to promote the technology, and properly engage with communities, they themselves find this task challenging. Neil Alexander, a long-time industry leader, noted that the industry tended to only actively communicate with the public in response to a crisis rather than proactively promoting the benefits of the industry on a regular basis (pers. comm.). Others noted that while the "industry is very good at communicating with each other" the benefits of nuclear power, they struggle to convey that same message to the public (J. Shikaze pers. comm.). While

public engagement with host communities is conducted on a regular basis, broader engagement efforts are limited.

This has meant that industry communication efforts with the general public are often fragmented and episodic. Jeremy Whitlock (pers. comm.) lamented the fact that the industry was letting events like Fukushima drive the discussion on nuclear power. Whitlock contended that if the industry had been regularly investing in communication, they would have established the level of trust with the public needed to effectively communicate during a time of crisis. "They [the public] shouldn't find out about radiation when something bad happens in Japan, and then all of a sudden these numbers are showing up on the front page without any context" (Whitlock pers. comm.). Whitlock was referring to radiation doses being reported in the aftermath of the Fukushima-Daiichi accident on March 11, 2011. The public for the most part does not know what a millisievert is, let alone what an acceptable dose of radiation is, so the numbers being reported in the press following the accident only served to raise alarm as opposed to inform the public. Sustained engagement and communication with the public would be needed in order to properly convey these issues to the public. A good relationship would have helped the nuclear industry to assure the public that the Canadian industry was capable of responding to a similar crisis at home should it be necessary. This trust and understanding, according to Whitlock, cannot be built overnight. Reactive communication strategies have only made responding to events like Fukushima that much more difficult given the lack of rapport with the public.

The Canadian nuclear industry has instead often relied on its record of safe operations to keep them out of the crosshairs of negative media reports and public

opinion. Alastair McIvor, a senior director at CNL, asserted that while safe operations may be boring, in this context it is a good thing, and would help the industry continue to make the case "that nuclear is a useful and valid component of the energy mix in Canada" (pers. comm.). Safe operations in many ways reflects how engineers have driven the nuclear discussion in Canada. The Canadian industry regularly boasts about the success of the CANDU design as a scientific and technical crowning achievement for Canada, but does not know how to translate this message for the broader public. They struggle to find the kind of messaging needed to reach a broader audience.

While they acknowledge the communication challenges they face with the broader public, from their perspective opposition to nuclear power is not what is holding up new development. James Scongack, Vice President of Corporate Affairs at Bruce Power, cited public opinion polling conducted by the utility company that found 7 in 10 Ontarians "support the refurbishment of nuclear in the province" (pers. comm.). A more recent study published by Bruce Power suggests that 81 percent of Ontarians support the refurbishment of the province's NPPs (Bruce Power 2015b).[173] Scongack suggests that market forces were the real driver that led Bruce Power to focus on refurbishment over new builds, not a lack of social acceptance.[174] Scongack seemed confident that should Bruce Power revisit this decision in the future, that the community would get behind a new build. He highlighted the fact that 12 000 people had signed a petition in favour of a

[173] The telephone survey of 600 Ontarians was conducted by Innovative Research Group September 15-22, 2015. In this survey, it was reported that: 41 percent strongly support, 39 percent somewhat support, 10 percent somewhat oppose, and 9 percent strongly oppose refurbishing Ontario's NPPs.

[174] Scongack noted that refurbishment would be more economical than new builds for Bruce Power. He also cited the province's low growth in demand as another factor that shaped their preference for refurbishment.

new build when they last considered the idea of new capacity on site (pers. comm.). Bruce Power for their part have not taken local support for granted. They have worked hard to maintain a high level of public support by working with the local community in order to "earn people's confidence" and maintain a "social licence to operate" (ibid.).[175]

John Stewart of the CNA also seemed to downplay public opposition to nuclear power, suggesting that "to call it public opposition is going too far" (pers. comm.). Instead, he asserted that the opponents seen at CNSC hearings were a small group of agitators not representative of the broader Canadian public. Stewart notes that it is the same small groups of dedicated individuals showing up to hearings to oppose any nuclear-related project. According to Stewart, these lifelong anti-nuclear activists do not have any desire to have a "rational conversation" based on facts, and merely want to stoke fear into the public about all things nuclear when they attend these hearings. This frustration was relayed to me by many people I interviewed who attended CNSC hearings from industry and the regulator.[176] It is clear that the adversarial relationship between environmental groups and the nuclear industry (and by proxy the regulator) has created a relatively toxic environment at public hearings. But if we set aside the combative and often testy exchanges encountered by industry officials and the regulator at these hearings

[175] Bruce Power outlined its commitment to maintaining social licence and the outreach work that they do in the local community in their 2015 Licence Renewal Briefing for the CNSC. It includes a variety of programs meant to support community health and wellness, youth development, and aboriginal groups.

[176] Francois Rinfret (pers. comm.) of the CNSC noted a deep frustration in dealing with some opponents of nuclear power who in his experience have been unswayed by objective evidence presented to them: "You always hear from a certain breed of individuals, and they monopolize a lot of our time, and some of those you cannot satisfy. No matter how I put it, no matter which words I use, what demonstration you have, with science and engineering, it can never be good enough."

from environmental groups, is there independent evidence to support the claim that this is only a small minority of Canadians that oppose nuclear power?

There is evidence to suggest that nuclear power does enjoy a reasonably high level of support in Ontario, but it remains a divisive technology nationally. A 2012 study conducted by the Innovative Research Group on behalf of the CNA found that while nuclear power enjoys a high level of support in Ontario (54 percent), nationally that number drops considerably (37 percent).[177] To put those numbers in context, the study notes that only coal power generation is less popular than nuclear power nationally. While industry can highlight the strong level of support for the technology in the province of Ontario and for the planned refurbishment of its fleet, it is misleading and disingenuous to suggest that opposition to nuclear power is limited to a small band of anti-nuclear activists.[178]

In recent years, industry has floated the idea that concern over climate change has led environmental groups and environmentalists to support nuclear power. The nuclear industry in Canada (and abroad) has begun to promote high-profile climate scientists and environmentalists who have publicly come out in support of nuclear power such as Carol Browner, James Lovelock, and James Hansen as evidence of this trend (CNA n.d.). This narrative has been further promoted by the documentary *Pandora's Promise* (2013), a film that spoke with former critics of nuclear power who now actively support the

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[177] It was a national telephone survey, with a sample size of 1304 conducted over ten days between May 2-12, 2012. They contrasted these findings with data collected between April 14-21, 2011, to track attitudes one year after Fukushima (Innovative Research Group 2012).

[178] The same 2012 Innovative Research Groups survey found that 63 percent of Ontarians support refurbishment. By contrast that number drops to 47 percent nationally. Support for new build is much lower at 48 percent in Ontario, and 33 percent nationally.

technology, including Stewart Brand, Gwyneth Cravens, Richard Rhodes, Michael Shellenberger, and Mark Lynas.[179]

The idea that environmentalists were softening their stance towards nuclear power was a narrative that industry officials were comfortable discussing in lieu of addressing the deeper political, ethical, and legal challenges that these opposition groups represented. When I interviewed industry officials, and asked about the judicial review of the Darlington EA and the role of environmental groups in the broader discussion on nuclear power, I received some surprising answers. For example, Dr. Robert Walker, former CEO of AECL/CNL, disagreed with the notion that environmental groups are in general opposed to nuclear power, and argued that their positions are in fact quite varied:

> I see evidence of environmentalists that are willing to get beyond dogma and are coming back and refreshing their thinking on nuclear energy with this news coming out of the IPCC [Intergovernmental Panel on Climate Change]. And I would argue to some degree here this is a reflection of environmentalists being prepared to look at nuclear energy in a cross-benefit context as a whole and actually compare it on the same terms with alternative solutions to energy needs and that is a voice that is emerging, a collective voice that is emerging of people that brand themselves as environmentalists.[180]

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[179] The documentary was recommended to me by three industry participants, and alluded to by a fourth in a positive light. The documentary was also raised by John Bennett from the Sierra Club; however, he saw it as a form of propaganda. I neither referenced the film in my interview questions nor solicited comment about it in any way.

[180] This is an excerpt from a much longer response to a question about public opposition to nuclear power and the role of environmental groups. On the question of the Darlington Judicial Review Dr. Walker had noted that it was not an appropriate place for the EA to be challenged and that it served to undermine the regulator. He was concerned that legal forums were being used to circumvent expert opinion and independent regulatory review. He worried that this might stymie investment in industry and hurt development. What he had taken issue with was my characterization of environmental groups as being opposed to nuclear power. I had asked: "One very specific element of the public is the environmental movement which has expressed very negative opinions on nuclear for a long time. Perhaps what is more interesting to me is the case that they have brought before the courts challenging the environmental assessment process as it pertains to the proposed new builds at Darlington. I am curious, what role do you think environmental groups have played in shaping how the nuclear industry operates in Canada? How has

While Dr. Walker and others are right to acknowledge a gradual shift in tone by certain individual environmentalists and activists, this narrative tends to minimize the influence of environmental groups, like Greenpeace, the Sierra Club, and others who continue to actively protest against the use of nuclear technology in Canada. When environmental groups are acknowledged by industry, they are presented as a small minority of the public who are ideologically-driven, obstructionist, and not susceptible to rational discussion based on science. The antagonist nature of this relationship makes communication between industry and its critics challenging to say the least.

Federal EAs and Public Consultation: Room for Improvement

While environmental groups and elements of the public might continue to use regulatory hearings as a platform to criticize industry and to stimulate a broader discussion on social acceptability, the regulator insists that this is not the appropriate forum. But if a proponent has failed to conduct sufficient community outreach to satisfy critics of their project, where is the appropriate forum for interest groups and members of the public to express their concerns? This is an ongoing issue for Federal EAs throughout the energy sector. While public scrutiny has been principally directed at the National Energy Board (NEB) and their regulatory process for pipelines, the ongoing federal review of the EA process will have implications for the CNSC as well.

The CEAA 2012 legislation was meant to streamline the federal EA process, but in practice has shown little if any improvement in terms of getting projects approved and

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this changed over time?" (pers. com.). The block quote included in the text of this chapter was in the first part of his answer.

built. This extends to both pipeline construction as well as nuclear reactors, as we saw in the case of Darlington. A review of this process was identified as a top priority following the 2015 Federal Election for the newly minted Environment Minster, Catherine McKenna (Trudeau 2015). As a result, a formal federal review the of the CEAA 2012 legislation was undertaken in an effort to rebuild public confidence in the process. The loss of public trust was identified by Justin Trudeau's Government as a key irritant that was leading major infrastructure projects to stall (ibid.). As part of the review, an expert panel led by Johanne Gélinas was commissioned by the Federal Government to study the matter.

In their submissions to the expert panel, regulators like the CNSC and NEB defended their role in the EA process as Responsible Authorities.[181] They highlighted the importance of bringing their expertise to bear on these highly technical projects, and the value added in their integrated licensing process. The public, by contrast, felt that the current process lacked transparency and impartiality. The final report by Gélinas et al. (2017: 49) noted; "the apprehension of bias or conflict of interest, whether real or not, was the single most often cited concern by participants with regard to the NEB and CNSC as Responsible Authorities." Intervenors from the public feared that the process had a baked-in bias that favoured proponents of a project from the outset, leading many to lose confidence in the process. The report went on to note that:

[181] The CNSC and NEB are referred to as "responsible authorities" under CEAA 2012. What this means in practice is that they are the federal organization charged with conducting federal EAs within their respective jurisdictions/mandates. All federal EAs not related to nuclear power or pipelines would be conducted by the Canadian Environmental Assessment Agency.

> [It] has led some to believe that outcomes are pre-ordained and that there is no use in participating in the review process because views will not be taken into account. The consequence of this is a higher likelihood of protests and court challenges, longer timeframes to get to decisions and less certainty that the decision will actually be realized – in short, the absence of social license (ibid.).

Following an extensive 21-city consultation process, the expert panel prepared a report released on April 5, 2017, which among other things called for: better access to public hearings for intervenors, the need for indigenous consultation at the outset of a project, and the creation of an independent federal authority to conduct all impact assessments for future projects (Gélinas et al. 2017).[182] This would in practice transfer the authority from Responsible Authorities, like the CNSC and the NEB to conduct federal EAs, to a newly formed independent body. In their final report, the expert panel asserted that: "an authority that does not have concurrent regulatory functions can better be held to account by all interests than can entities that are focused on one industry or area and that operate under their own distinct practices" (Gélinas et al. 2017: 50). Gélinas et al. (2017) emphasize that this change is part of a broader effort to make the process as impartial as possible and "remove any perceived notion of bias" (ibid.).

In summary, the expert panel asserted that any future process had to be: inclusive, transparent, informed, and meaningful. What this process will look like in practice remains to be seen. Minister McKenna and the Trudeau Government have responded positively to the report, but have not indicated whether they will adopt any or all of its recommendations (McDiarmid 2017).

[182] The term impact assessment is meant as a rebranding of the EA process, coined by the expert panel.

There are some clear indications that questions of social acceptance will likely become incorporated into a revised Federal EA process, but the specifics remain to be seen. How the CNSC and the nuclear industry will cope with this kind of change could prove interesting. Industry will clearly need to find better ways of engaging with its opponents. Their current strategy has not closed the door on new builds in Ontario, but it risks doing so if critics and public opposition to the technology are not adequately addressed in the near term.

As noted in chapter 2, opponents of nuclear power cannot be simply dismissed as being driven by NIMBY concerns, or assumed to be misinformed on the issue (i.e. the knowledge deficit model). Opposition to nuclear power is a deep-seated debate about values, driven by a segment of the population that has lost trust in the regulator and the industry. They remain deeply skeptical of industry claims of safe operations and view any benefit derived from nuclear power as simply too risky. Based on their antagonistic history, these groups are unlikely to pursue any kind of reconciliation with one another.

Environmental groups like the Sierra Club and Greenpeace are not (and probably should not be) the target audience of any new communications strategy undertaken by the nuclear industry. Instead, stakeholder engagement initiatives should focus on the broader public, not presently engaged in the debate over Ontario's energy future. Given the strong preference for renewables in Ontario, a successful campaign for nuclear power should seek to frame the technology as an accoutrement to green energy (i.e. wind and solar) as opposed to a replacement. It is likely that something akin to "reluctant acceptance" as described by Pidgeon, Henwood et al. (2008) in the UK, might continue to be the status quo for Ontario as opposed to robust support for the technology.

When looking for examples of effective stakeholder engagement, one oft-cited success story from my interviews is the work of the Nuclear Waste Management Organization (NWMO). They are an industry-led, federally mandated group, charged with finding a socially acceptable approach to handling Canada's HLW. The next section provides a brief history of the issue of HLW in Canada, the emergence of the NWMO, and their approach to engagement with local communities as they seek to garner the trust and acceptance needed to advance their plans for a permanent DGR.

Nuclear Waste and Deep Geological Disposal

The issues surrounding the management of HLW produced by nuclear power plants has dogged the industry for decades. One of the earliest calls for a permanent form of HLW storage comes from a 1977 report commissioned by the Minister of Energy Mines and Resources (the predecessor to NRCan) known as the Hare Report.[183] This finding was reiterated by a provincial Royal Commission, known as the Porter Commission in 1978.[184] That same year the Federal Government and the Government of Ontario through a joint statement called on AECL to explore the concept of deep geological disposal of nuclear waste. In 1981, it was determined that no site would be selected until the technology had been developed and vetted by a complete public hearing process ("How is High-Level Nuclear Waste Managed in Canada?" Nuclear FAQ 2011). In 1988 the matter was referred to public review by the Federal Government. The panel was chaired by Blair Seaborn, which began its review in the fall of 1989 as part of the

[183] It was named after its chairman, F.K. Hare. Its formal title was: *The Management of Canada's Nuclear Wastes*.
[184] It was named after its chairman, Arthur Porter. Its formal title was: *A Race Against Time Interim Report on Nuclear Power in Ontario*.

federal EA process. It was tasked with reviewing the "safety and acceptability of AECL's concept of geological disposal of nuclear fuel wastes in Canada" with no determined site or specific project being assessed by the panel (CEAA 1998).[185]

AECL provided the panel an EIS in 1994 that outlined a technical proposal for deep geological disposal meant to store the waste safely for up to 10 000 years after the closure of the facility. The plan was to transfer waste from existing interim facilities situated at NPPs to a centralized facility. The waste would be put into special containers and then stored in an underground facility (500m to 1000m below the surface) in a seismically stable part of the Canadian Shield, with a plan to eventually seal the facility to make the site "passively safe" (CEAA 1998). This would remove the need for long-term monitoring of the spent fuel and reduce the risk of accidental exposure to future generations following the closure and decommissioning of the facility. Deep geological disposal would ensure that future generations would not have to shoulder the cost or responsibility of dealing with waste that they did not produce, nor derive direct benefit from. So while existing interim storage measures remained safe, this was meant as an added confidence building measure for the public that there was a plan in place that would deal with the long-term dangers posed by the back-end of the nuclear fuel-cycle.

After many years of hearings with diverse communities across the country, and a thorough review of the EIS submitted by AECL, the Seaborn Panel issued its final report in 1998. The panel found that: "from a technical perspective, [the] safety of the AECL

[185] The specific terms of reference can be found in Appendix A of the panel's 1998 report (CEAA 1998). Critics of their mandate note that it did not allow the panel to consider the broader implications of the continued use and expansion of nuclear power in Canada and instead focused on the very narrow question of HLW (Durant and Stanley 2009).

concept has been on balance adequately demonstrated for a conceptual stage of development, but from a social perspective, it has not" (CEAA 1998).[186] The panel recommended the formation of an arm's length agency from industry to study the options for nuclear waste management in Canada in order to ensure that the public could have confidence in the independence of the process.[187] It called on that agency to engage in a robust consultation process with the public, along with indigenous groups on both the DGR concept and the siting of the potential facility. This process was meant to produce a socially and technically feasible option for Canada's HLW.

These findings forced industry and policymakers to incorporate the question of social acceptability into their plans for the long-term management of HLW. Technical assessments of safety were no longer viewed as a sufficient metric to assess the acceptability of a plan for Canada's HLW.

In response to the Seaborn Panel's Report, the Federal Government passed the 2002 *Nuclear Fuel Waste Act* (NWFA). This legislation created the NWMO, a not-for profit corporation, paid for by industry.[188] The NWMO was mandated to study Canada's options for HLW, present those options to Canadians, and ultimately implement the plan produced by this consultation process. This led to a three-year, $24 million public

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[186] It is worth noting that this finding was not a new one. A.M. Aikin (1980: 217), a member of the 1977 Hare Report asserted that the issue of nuclear waste management in Canada was "an institutional and political problem, rather than a technical one" almost 20 years earlier.

[187] The panel felt this was necessary because "a significant portion of the public did not trust the nuclear industry and the regulatory agency," at that time (CEAA 1998).

[188] Industry in this case includes: OPG, New Brunswick Power Corporation, Hydro-Québec, and AECL. They are required to make annual contributions to NWMO to support the organization in its mandate (NWMO 2017b). As producers of that waste, they are all legally responsible for its permanent disposal.

consultation that included over 150 sessions, with approximately 18 000 Canadians (Johnson 2015; Wilkins 2015). In 2005 the NWMO recommended to the Federal Government what they referred to as Adaptive Phased-Management (APM) to deal with Canada's HLW. The plan was approved by the Federal Government in 2007.

APM has many parallels to AECL's technical plan. APM calls for a permanent deep geological storage facility that centralizes Canada's HLW, much like the AECL technical concept, but with a "phased and adaptive decision-making" process (NWMO 2005: 23). In practice, this would provide NWMO with the flexibility to alter the pace and manner in which the plan was executed on an as needs basis. NWMO insists that "the emphasis is on adaptability. Through a phased process with explicit decision points, new knowledge and technology can be accommodated as can the societal change that will be inevitable over time" (NWMO 2005: 32). While their consultation process may have in many ways endorsed key elements of AECL's technical plan, NWMO argues that APM's emphasis on adaptability and social considerations are important distinguishing features.[189] According to NWMO, APM is designed to help foster the trust and social acceptance needed for a project of this kind to be successful.

Echoing the recommendations of the Seaborn Panel (CEAA 1998), the NWMO would seek a willing and informed host community as part of their site selection criteria (NWMO 2005).[190] The NWMO's approach "appeared to represent a distinctive turn in policy formulation away from a closed-door, elite-centered process…toward a more

[189] Critics like Genevieve Fuji Johnson have highlighted the many similarities between AECL's technical proposal and NWMO's APM. Johnson (2015: 83) notes that APM "could be understood as deep geological disposal mapped out on a realistic timeline."
[190] The site would still require the appropriate geology to be capable of hosting a DGR.

open, inclusive, and participatory process" (Johnson 2015: 76). Critics have suggested that NWMO's elaborate public consultation process was simply a means of legitimizing the industry's preference for a centralized DGR (Durant 2009; Johnson 2009; Johnson 2015).

From 2008 to 2010 NWMO undertook another public consultation to determine the best means of conducting their site selection process. In May 2010, the NWMO officially launched their search for a willing host community. Initially there were 22 communities interested in being considered as sites for the DGR, however that number has since been whittled down to seven (NWMO 2017c; NWMO 2017d).[191] The NWMO has been reluctant to provide firm deadlines for the siting process, but if current assessments go ahead as planned, they believe a preferred site could be selected by as early as 2023 (NWMO 2015: 33). This suggests that we are at least six years away from a community being formally asked to host the site. Only then would an EA be initiated along with the appropriate regulatory process to licence the site. Following the regulatory approval process, an additional 10-years would be needed to build the DGR (NWMO 2017a). At this rate Canada will be without a permanent HLW facility for two decades at a minimum.[192]

[191] The remaining seven communities are all situated in Ontario. They include: Blind River, Elliot Lake, Hornepayne, Huron-Kinloss, Ignace, Manitouwadge, and South Bruce. It is worth noting that five of the seven remaining communities are in Northern Ontario.

[192] This is a rather conservative estimate. There has not been any serious discussion of potential delays that might arise from: an untested regulatory process, political interventions, public backlash in the host community, or technical problems that may be encountered during the construction of a DGR.

Coming back to the question of social acceptance, while waste remains a point of serous contention amongst opponents of nuclear power in Canada, it was not perceived as a serious impediment to nuclear development in Ontario. While the issue of long-term waste management was raised by the 2014 Judicial Review of Darlington's EA, it ultimately was dismissed on appeal. It has not really been an issue for the Federal or Provincial government since the creation of the NWMO. The CNSC for its part asserts that there are no immediate risks to the public or the environment if nuclear fuel remains in interim facilities (S. Locatelli pers. comm..). While a plan for HLW has been flagged by industry as "key to gaining public confidence and maintaining social licence to build new reactors" (Walker 2014: 63), there appears to be no rush to build such a facility. So long as the NWMO process continues to move forward, albeit slowly, it seems to be sufficient to allay most public and political concerns over the issue. Whether the NWMO approach has something to teach industry about incorporating the question of social acceptance into how it approaches new projects, or engages with the public is a different matter.

Public Consultation and Stir: Lessons Learned?

Many industry stakeholders that I interviewed for this dissertation cited the NWMO process as a model for what consultation and public engagement should look like for the industry moving forward. It has been lauded for its lengthy consultations with diverse communities potentially affected by the proposed DGR, the quality and quantity of information provided to those participants, and above all, their efforts to make the process fair and equitable (Johnson 2015). The flexibility provided by APM is designed to ensure that the consultation process is not rushed in any way. This has given NWMO

representatives ample opportunity to build the type of relationships required to advance their aims. This has meant taking the time and devoting the resources necessary to finding a willing and informed host community to site, build, and operate a permanent HLW DGR.

To that effect, they have funded the creation of Community Liaison Committees (CLCs), comprised of local part time staff in each of the potential host communities. CLCs are meant to help facilitate interactions between the NWMO, the public, and the municipality itself. They are used to hold regular open house sessions in these communities, and to provide information and updates about the proposed DGR (B. Lloyd, pers. comm.; Van Brenk 2016). Their mandate is to "engage, educate, and listen to the community…[and] to provide advice to the Council of the Municipality regarding NWMO's Site Selection Process and Adaptive Phased Management" (Blind River Community Liaison Committee, n.d.). Put simply, CLCs are meant to serve as an institutional mechanism that helps to facilitate the consultation process within each of the respective NWMO communities. The NWMO has also provided an initial investment of $400 000 to interested communities who complete the first phase of their assessment process (Wilkens 2015; Van Brenk 2016). These investments serve to strengthen their bonds with those communities and help to ensure that the costs associated with taking part in the NWMO process are covered by the proponents of the project.[193] Critics of this process are less charitable in their assessment of the CLCs and their approach to stakeholder engagement.

[193] In addition to the $400 000 community improvement fund, the NWMO has said that it will cover up to $75 000 per year of expenses associated with NWMO activities including operating the CLCs, hospitality, and travel expenses (Wilkens 2015).

Opponents of the NWMO like Brennain Lloyd of Northwatch assert that they provide the illusion of being an open and fair process, but that they are in fact neither. "So what we have really is a sham of a process. It is very detailed, the graphics are great, the books are slick, the meetings are awesome, but it is exclusion through inclusion" (Lloyd pers. comm.). CLCs and the NWMO site selection process have been criticized for being largely driven by local municipal officials as opposed to the broader public (Lloyd pers. comm.; Johnson 2015).[194] Genevieve Fuji Johnson suggests that these initiatives may simply be a means of extending "elite discussions" between municipal governments and the NWMO under the guise of public consultation (Johnson 2015: 91).

Johnson (2009; 2015) contends that the consultations first used to develop APM process (2002 to 2005) gave the false impression that the public would have a voice in how HLW would be managed and that their views would inform public policy. Instead, they were used as pawns to provide a "veneer of public acceptance for a predetermined plan" (Johnson 2015: 86). Johnson remains doubtful that this dynamic will change during the site selection process.

[194] Lloyd argues that the NWMO is simply trying to fulfill the mandate set out by the Seaborn Panel and get a community to proffer some form of social acceptance or social licence for its proposed DGR. The CLCs' meetings and information centers give the impression of a robust consultation, but according to Lloyd, it is in fact quite limited. Lloyd asserts that only a handful of people are attending these sessions, with few if any opportunities to challenge the information being presented to them. "It is not public consultation, it is not engagement, it is not…you know, there are few if any opportunities for community members either through the public information centers, or through the community liaison committees to really test what the NWMO is presenting to them, to hear alternative information, to evaluate it through any means other than the NWMO with some very expert public relations employees, who are going to talk to them about it [*sic*]" (Lloyd pers. comm.).

There have already been some signs of tension during the site selection process. Protests from local NGOs, First Nations, and concerned citizens led to places like Saugeen Shores, Ontario, and Creighton, Saskatchewan, being removed from the NWMO process (Naylor 2014; Wilkins 2015). This suggests some degree of responsiveness on the part of the NWMO to political opposition and protest. That being said, there remain serious concerns over how a potential host community will make the final decision to host the DGR. Some local politicians have made clear that a referendum will have to take place in order to ensure that the proposed DGR enjoys the support of the community. The mayor of South Bruce, Robert Buckle, has stated publicly: "I will insist that we have a referendum. Something as important as this I'm not going to let six people (on council) make that decision" (quoted in Van Brenk 2016). This, however, is not a requirement of the NWMO process. For their part, the NWMO have suggested that a community might demonstrate its willingness to host the DGR in variety of ways including but not limited to: "documented support expressed through open community discussions or town hall meetings, a telephone poll, online meetings or surveys and/or a formal referendum" (NWMO 2010: 20). It is still too early to say whether further tensions will arise from this process when a site is finally selected by the NWMO.

By contrast, tensions over OPG's plans to build a DGR for low and intermediate level waste at the site of the Bruce NPP in Kincardine have already begun to boil over. Unlike the NWMO, there was no search for a site. OPG already owned the land surrounding the Bruce NPP and has operated the above ground Western Waste Management Facility there for over 40 years. The Western Waste Management Facility is the interim facility responsible for isolating low and intermediate waste from Ontario's

18 nuclear reactors. Efforts to advance the construction of a permanent DGR for low and intermediate waste have been underway for 15 years, with the community of Kincardine agreeing to host the facility in 2004 (OPG 2016a).

Like the Darlington new build, the OPG DGR has already been evaluated by a JRP. The JRP found the project to meet the requirements for an EA in May 2015 (CEAA 2015). Under CEAA 2012, the Environment Minister has the final say on whether the project can proceed. Following the election of the Liberal Government in 2015, the newly appointed Environment Minister Catherine McKenna called for additional studies to be undertaken by OPG prior to making a final decision on the project. This is an interesting case because it is a project that has been vetted by experts and found to be technically safe (CEAA 2015b; CEAA 2017). It is also a project that enjoys the support of the host community in Kincardine. That being said, the OPG DGR has elicited strong criticism and opposition from neighboring communities both in Canada and the US as well as the Saugeen Ojibway Nation (SON). Over 180 communities that surround the Great Lakes have passed resolutions calling for the project to be vetoed over concerns that leaks might contaminate the drinking water of approximately 40 million people (Friess 2016).[195] In the US, the Michigan State Senate passed a resolution demanding that the White House invoke the *1909 Boundary Waters Treaty* to put a stop to the DGR,[196] while a bipartisan group of 32 US Congressmen have sent a letter to the Liberal Government to halt the

[195] For a complete list of these resolutions see: (Stop the Great Lakes Nuclear Dump n.d.).

[196] Given their concern over the Great Lakes, they suggest that the OPG DGR can be seen as a waters dispute, bringing this treaty into play as a mechanism to resolve the issue.

project (ibid.).[197] In Canada, opposition from the SON could become a serious sticking point given that the Bruce site is on their traditional territory. OPG has assured their leadership that a DGR will not be built without their consent. Both OPG and the SON are working towards resolving this impasse, but no resolution has been announced as of yet (Gowan 2015). OPG for their part issued a statement in April 2016, noting that they will complete the additional studies requested by the Federal Government to prove that the science behind the project is sound. They remain confident that "a DGR is the right answer for Ontario…and that the Bruce site is the right location" (OPG 2016c). The formal decision has since been postponed by the Trudeau Government and shows no sign of being resolved quickly.[198]

What we see in the case of the OPG DGR not yet discernable in the context of the NWMO site selection process are some of the complexities of securing social and political acceptance. While OPG presently enjoys the support of the host community of Kincardine, a strong opposition has emerged on both sides of the US-Canada border from communities surrounding the Great Lakes to their proposed DGR. Additionally, we are observing the emergence of a potential veto from First Nations communities in the region that might further frustrate the process.

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[197] It is worth noting that in 2012 both the US Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality issued statements assuring lawmakers that they had no overriding concerns with the project (Friess 2015).

[198] The Trudeau Government extended their review by 243 days as of December 12, 2016. On April 5, 2017, the Canadian Environmental Assessment Agency requested additional information on among other things, OPG's assessment of other sites and their mitigation plans. They claim more information is still needed to meet the Minister's original request from February 2016. This request for more information is likely to further delay any decision on the OPG DGR construction licence. For ongoing developments related to the OPG DGR and its EA process see: (CEAA 2017).

The NWMO for their part have responded to the OPG case, noting that the Environment Minister's "request for information does not affect the NWMO's work with respect to leading a site selection process for Adaptive Phased Management (APM)" (NWMO 2016). Two of the seven NWMO communities are located in and around the Bruce site. The OPG case could prove far more relevant to the NWMO's site selection process than they care to admit. There is still plenty of time for the NWMO to adjust their site selection process if necessary, but if their communication strategy is any indication of what is to come, it appears to be reactive rather than proactive. While many elements of the NWMO's approach to stakeholder engagement and communication deserve to be lauded, it is still too early in the process to know whether it will be successful. Major conflicts are not likely to emerge until much later in the process. While some lessons can be drawn from the NWMO experience, their emphasis on garnering social acceptance from the local community fails to address the broader challenges a DGR might attract from neighboring regions. The OPG DGR experience should serve as a cautionary tale to the NWMO and the Canadian nuclear industry of the kind of backlash that they might experience in spite of a strong consultation campaign. Opposition emanating from diverse constituencies outside of the host community will remain a difficult circle to square for any proponent.

Refurbishment Going Ahead

The plans outlined in the 2013 LTEP for the refurbishment of 8500 MW of capacity at Darlington and Bruce have begun to take shape. OPG's four Darlington units will be the first to be refurbished. Work began at Darlington Unit 2 in October 2016, for what is expected to be a 42-month process. The entire project at Darlington is expected to

cost $12.8 billion and take 10 years to complete. To help pay for this refurbishment, OPG is expected to look to the OEB for a rate increase. When the project was announced on January 11, 2016, the Ministry expected an increase from 5.7 cents per kilowatt hour to between 7 and 8 cents (MOE 2016).[199] OPG is the only major utility still subject to the OEB's regulatory process. The refurbishment is being presented by OPG as an economic opportunity for Ontario. The refurbishment project is expected to create upwards of 8800 jobs, and provide an economic benefit of $14.9 billion to the province (Bounajm and Antunes 2015). OPG notes that the 30-year life extension of the NPP will also help to preserve 3000 personnel at the plant (OPG 2016b). They also note that the refurbishment project led by a Aecon Construction and SNC-Lavalin Nuclear will include upwards of 60 suppliers based in Ontario (ibid).

In the case of Bruce Power, six of its eight units will be refurbished at a cost of $13 billion. The refurbishment is expected to begin in 2020 and take 15 years to complete. A new long-term contract was negotiated with IESO, similar to the agreement for the Bruce A refurbishment back in 2005; it provides a fixed price for the output of the entire plant (6300 MWe).[200] As of January 1, 2016, the price was set at 6.57 cents per kilowatt hour, increasing to 7.7 cents when the refurbishment is complete (CP 2015). Like the Darlington project, it is being heralded as a positive economic development for

[199] The rate is now expected to be slightly higher than originally anticipated. OPG applied for a 69 percent rate hike on June 1, 2016. That would bring their price on nuclear up from 5.7 cents to 9.0 cents per kilowatt hour (Leslie 2016). The final rate will ultimately be determined by the OEB sometime next year.

[200] The 2005 agreement set a rate of 6.3 cents per kilowatt hour from the Bruce A units, and a 4.5 cent floor price for the Bruce B units (WNA 2017f). The contract was designed to incentivize the $4.25 billion private investment into the Bruce A units. For a more detailed discussion on this matter see: (Office of the Auditor General of Ontario 2007).

the province, creating over 23 000 jobs directly and indirectly as a result of the refurbishment, and approximately $6.3 billion per year in "local economic development" (Benzie 2015). The way the agreement is structured, the risk of cost overruns is borne by Bruce Power, and not the ratepayer. Ultimately the ratepayer will only be responsible for the rate negotiated by the IESO, a price well below the 9.89 cents per kilowatt hour average in 2015 (WNN 2015a). The amended agreement between the IESO and Bruce Power is being presented as a transparent, low cost option for the ratepayer, that will ensure that province's largest NPP continues to provide a large portion of the province's electricity supply well beyond 2060.[201] The deal provides the province the flexibility to reassess its plans based on market conditions over time. This means that the province may not ultimately refurbish all six units at Bruce if the industry is unable to deliver the projects on time or on budget. The idea that "off-ramps" might limit the number of units refurbished is in line with the LTEP's overarching goal of being both flexible and pragmatic in its plan to maintain an electricity supply that is cost-effective, reliable, and clean (MOE 2013: 4).

Ultimately the province and industry have presented a narrative of refurbishment being part of an affordable long-term solution that is a good investment needed to help boost Ontario's ailing economy. Minister of Energy Bob Chiarelli[202] heralded these agreements at the time as multi-billion-dollar investments in the province's infrastructure, that will create high levels of employment while cutting hydro bills for the average

[201] Refurbishment is thought to add between 25 and 30 years to each of these units. With the last unit at Bruce being completed by 2035, current projections expect it to operate until 2064.

[202] Following a June 2016 Cabinet shuffle, Chiarelli was moved to Infrastructure. Glenn Thibeault is the current Minister of Energy in Ontario.

ratepayer (Benzie 2015; MOE 2016). In addition to trumpeting the economic benefits of nuclear power for the province, industry has also been keen to highlight its role in helping Ontario transition away from coal (Bruce Power 2015a; WNN 2015a). This framing seems to have effectively dampened any strong opposition to nuclear power following the announcement of these two major refurbishment projects.[203] The idea of expanding Ontario's nuclear fleet now seems like a distant memory. Instead the focus has clearly shifted to maintaining core capacity at the Darlington and Bruce sites in the years to come.

Conclusion

For decades Ontario built and supported a nuclear power program responsible for producing over half of its electricity. That support began to waver during the 1990s as a result of costly overruns, delays, and underperformance. Changes to Ontario's electricity market led to improved performance from the province's fleet and to a cautious optimism that nuclear power could continue to play a key role in the supply mix moving forward. Following the restructuring of Ontario Hydro, the province became a strong supporter of the technology by advocating for large-scale refurbishment of its existing reactors and the pursuit of two new builds. Given that no new reactor had been ordered in the province since 1977, this was a significant development.

The Ministry of Energy's 2013 LTEP may have put plans for two new reactors on hold, but it continues to support the refurbishment of ten units at Bruce and Darlington

[203] It is worth noting that the Progressive Conservatives, the Official Opposition in the Province, have come out in favour of refurbishment (CP 2015). This is perhaps not surprising given the traditional support the industry has enjoyed from both the Liberals and PCs in the province (Bratt 2012). By contrast the NDP is against refurbishment, and has traditionally opposed nuclear power.

starting in 2016. This chapter focused on efforts made by the province to get two new units built at Darlington starting in 2006. It looked at some of the key factors that led to those plans being deferred indefinitely including: decreases in expected electricity demand, the high cost of the ACR-1000, and limited federal interest in supporting potential cost overruns associated with a project of this kind. The remainder of this chapter explored the issues surrounding the Darlington EA and the Judicial Review that it faced in 2014. It looked at how the question of social acceptance had been advanced by environmental groups, and the response that it had elicited from industry and the regulator. This chapter did not find social acceptance of nuclear power or nuclear waste to be significant barriers to nuclear development in Ontario. That being said, the battles over EAs and nuclear waste may be an indication of growing discontent. Improved communication and engagement with the public will be necessary to ensure that future projects are not derailed by these issues.

Today, the province is poised to begin work on a planned refurbishment of 8500MW of capacity at Bruce and Darlington that is expected to cost almost $26 billion and keep the province's reactors operating beyond 2060. The high level of demand for electricity seen in the early 2000s that caused Ontario to seriously consider new builds has faded into a distant memory following the 2013 LTEP. The NEB has suggested that while electricity demand in the province will begin to recover by the year 2040, that it is likely to be lower than levels seen in 2008 (NEB 2016). The loss of demand triggered by the 2008/2009 recession, in conjunction with the rapid adoption of renewables in the province, makes the expansion of nuclear power exceedingly unlikely in the years to come. Even if the province successfully implements its refurbishment plan, nuclear

power's role in the supply mix is expected to decrease in the years to come. The NEB projects that nuclear power will only make up 23.5 percent of the province's installed capacity by 2040 as a result of the closure of the Pickering Plant and the growth of renewables and natural gas during that period (NEB 2016).[204]

Industry appears to have missed its window of opportunity to add new capacity in Ontario. The high demand experienced in Ontario from 2005 to 2008 made new builds a sensible option for a province already highly reliant on the technology as a key source of electricity. But by 2013, it was becoming increasingly apparent to policymakers that a weakened manufacturing sector in the province could not support such costly and long-term investment. Ontario continues to be a province that is politically supportive of the industry, but it simply cannot make the business case for new reactors at this time. The 2013 LTEP reflects a commitment to maintaining nuclear power as a key part of the province's supply mix for decades to come. OPG and the province have preserved the ability to revisit the question of new build in the future, but there are few signs that this option will be exercised. Ontario's commitment to nuclear power beyond this round of refurbishment will depend heavily on whether a business case can be made such a substantial public investment. Future decisions on new builds might also be further hampered by a new federal EA process still under review. Early indications show an industry slow to adapt to calls for greater social engagement. The OPG DGR might prove a fertile testing ground for a new engagement campaign to demonstrate their ability to

[204] This is down from 36.8 percent in 2016. By contrast wind, solar, and biomass are expected to account for 28 percent of installed capacity by 2040 (NEB 2016).

engage people in a socially-aware and yet technically sound debate over nuclear power that is long overdue.

Chapter 6: Phasing Out Nuclear Power in Germany

Germany presents a different sort of case than Canada or Finland in an important way. The political discussion since the late 1980s in Germany has shifted from the question of *if* they should transition away from nuclear power to a question of *when*. Germany has been in the process of shutting down its nuclear power plants since an agreement between the major utility companies and the German Government was reached in June 2000. At the time, Germany operated 19 reactors, accounting for approximately 30 percent of Germany's electricity supply. Today only eight German reactors remain in service, generating roughly 14 percent of the country's electricity needs, with all units scheduled to be shut down by December 31, 2022 (WNA 2017e). This chapter explores some of the political factors that led Germany to begin the phase out of its commercial nuclear power program. These factors include: the effectiveness of a long-standing anti-nuclear movement, the growth of the Green Party, spurred by accidents like Chernobyl and Fukushima, and the corresponding loss of trust in the industry and its safety record. During the intervening years, the German Government and the utilities have failed to make a case to the public as to the value of nuclear power, and its role in Germany's energy future. While there were efforts to extend the life of Germany's reactors in late 2010, these plans became politically untenable following the Fukushima accident on March 11, 2011. Pitched political battles over reprocessing and the question of long-term waste management have only further contributed to the rejection of nuclear power in Germany.

Today, Germany has embarked on an energy transition known as *Energiewende*, which presents an alternative roadmap for achieving a low-carbon economy using

renewables in lieu of fossil fuels and nuclear power. Germany remains committed to an ambitious set of carbon reduction targets, and intends to do so without the assistance of nuclear power. This chapters sets out to explore what drove Germany to adopt this alternative path in a period where other countries continued to view nuclear power as a technology capable of playing a pivotal role in reducing carbon emissions.

This chapter will begin by providing a brief history of Germany's nuclear power program, followed by the growing anti-nuclear movement that emerged in response. It will then explore the early political responses that failed to deter the anti-nuclear movement in Germany, paving the way for the development of the Green Party during the early 1980s. While the emphasis of this chapter is on the phase out that emerged between 1998-2002, there is a need to provide some historical context to the social and political movements that led to the political consensus that emerged amongst all major political parties and the public on the nuclear issue. Finally, this chapter will explore the role of waste in the discussion, and the lingering legal and technical challenges Germany faces as it embarks on the process of shutting down, and decommissioning its remaining nuclear capacity as part of its *Energiewende*.

In this chapter, we will see that the policy decision surrounding the nuclear phase out was not made in the aftermath of Fukushima, but was a policy that had been developed, debated, and enacted over a much longer period of time. Germany's *Energiewende* reflects an alternative approach to a low-carbon future that emerged from this protracted societal debate over nuclear power. This chapter intends to provide an overview of how this political consensus emerged and what implications it has for Germany and its electricity sector moving forward.

A Brief History of Germany's Nuclear Power Program[205]

Following the Second World War there were a variety of restrictions placed on West Germany, which included a ban on civil and military nuclear research (Mez 2009). On May 5, 1955, the conclusion of the Paris Accords led to the lifting of restrictions on civil nuclear research in West Germany (Germany hereafter) (deLeon 1979). Initially a variety of reactor designs were under consideration, but only two out of a proposed five units were built. Siemens adopted the Westinghouse Pressurized Water Reactor (PWR) design, while AEG opted for using General Electric's Boiling Water Reactor (BWR) design (Mez and Doern 2009). By 1967 Germany was ordering its first commercial scale reactors; which included a 670MWe BWR at Wuergassen and a 672MWe PWR at Stade (Mez 2009). In 1969, Siemens and AEG merged their nuclear divisions to form Kraftwerk Union (KWU), the firm ultimately responsible for building Germany's 19 commercial reactors. By 1974, Germany had built the world's largest reactor, a 1200 MWe PWR at Biblis A. The success of their program at home led KWU to export reactors to countries like Iran, Argentina, and Brazil (Mez and Doern 2009).

The German Government had initially viewed nuclear power as a technological means of supporting its industrial and economic growth in the post-war years (Mez and Doern 2009). "Its importance derived not just from its capacity to meet Germany's energy needs after the oil crisis and from the export potential, but also from the

[205] To be more precise, this is a history of the West German nuclear program. All reactors operating today in the Federal Republic of Germany were built and operated in West Germany. All East German units were shut down following the reunification of Germany in 1990 over safety concerns and later decommissioned. At the time of reunification there were only four VVER-440 reactors in operation (WNA 2017e). Several other units that were built or under construction in East Germany remained offline and were later dismantled (IAEA 2016b).

employment that it generated in the electrical, engineering, and chemical industries" (Dyson 1982: 27). Following the 1973 Oil Crisis, the German Government issued a national energy program in which it called for a dramatic increase in the use of nuclear power, with plans to build up to 50 nuclear power plants by 1985 (Hatch 1991). It was an ambitious target meant to dampen Germany's growing dependence on imported oil.[206]

No major political party or social movement had raised any serious opposition to nuclear power in Germany at this time. This early period of nuclear development and planning reflected a "technological optimism which until the early 1970s was based upon a political consensus among the governing parties," that nuclear power should play a pivotal role in their energy policy (Mez and Doern 2009: 124). This period reflected a type of German Corporatism referred to as *Modell Deutschland* that "had emerged in response to the energy crisis and economic recession…[that] fostered a societal consensus rooted in economic growth" (Joppke 1993: 93). Nuclear power's development was linked to a narrative of economic development and growth (U. Waas pers. comm.). But this period of German optimism surrounding nuclear power proved to be relatively short-lived. It quickly became clear that neither economic growth nor nuclear power (or technology broadly speaking) could solve the deeper problems facing society.

The rapid expansion of Germany's nuclear reactors led to unexpected clashes with local groups over the siting of these facilities at various locations across the country. Starting in 1975, violent clashes at proposed nuclear sites including Wyhl, Brockdorf,

[206] In 1972, oil accounted for ~55 percent of the country's total energy consumption. The German energy program was designed to reduce that figure to 44 percent by 1985, while increasing the use of nuclear from 1 percent to 15 percent during that same period (Hatch 1991).

and Grohnde between police and protesters came to reflect the growing backlash against nuclear power taking root amongst the German public. Those interviewed for this chapter from industry acknowledged that while there were some organized efforts to engage the public at this critical juncture, they were not particularly effective in swaying public opinion.[207]

Wyhl is often cited as a turning point for the German anti-nuclear movement (Nelkin and Pollak 1982; Glaser 2012; Hatch 1986). Opposition to the Wyhl NPP brought together community associations (from local and neighbouring regions), the Protestant Church, university students, and scientists concerned about the environmental consequences of building such a facility in their community. They signed petitions, lobbied local politicians, made technical submissions to state regulatory authorities, occupied the construction site, organized mass protests, and filed court injunctions (Nelkin and Pollak 1982). They successfully got the construction licence (at least temporarily) revoked through a series of rulings in the courts from 1975 to 1977. Their success in blocking the development of a reactor at Wyhl taught the movement a number of key lessons: "it showed that a local population could maintain a high level of militancy, that endurance and good legal and technical advice could bring success in the

[207] Ulrich Waas (pers. comm.) participated in early efforts on behalf of industry during the 1970s and 1980s to talk to the public about nuclear power. At the height of this campaign, he said his company was hosting up to 300 events a month. He described going out and speaking at community centers and Lions Clubs, to educate the public on how a NPP worked. According to Waas, this strategy proved largely ineffective because they did not prepare the public for the risks associated with the technology nor did they listen to their concerns following accidents at Three Mile Island and Chernobyl. It was a classic case of one-way communication, where industry wanted to get their message out but did not want to engage in a genuine two-way dialogue with the public.

courts, that well-informed citizen initiatives could use the issue to raise fundamental political questions about democratic procedures…" (Nelkin and Pollak 1982: 63-64).

In short, it provided a template for how to frustrate and potentially derail Germany's nuclear power program moving forward.

While the anti-nuclear movement had not yet found a champion among Germany's political parties, the administrative courts' injunctions starting in 1977 served to hamper the construction of reactors across the country. In March 1977, the Administrative Court ruled that "insufficient provision has been made for a concrete containment vessel in the reactor design" for the planned NPP at Wyhl (Nelkin and Pollak 1982: 63).[208]

These early victories for the anti-nuclear movement served to encourage the development of their own experts needed to challenge the technical expertise of the nuclear industry and the regulator. Technical expertise had traditionally been used as a "justification for closed decision-making procedures" in the field of nuclear energy (Nelkin and Pollak 1982: 20). It was clear from cases like Wyhl that finding ways of successfully countering this technical expertise would be necessary for the anti-nuclear movement to succeed. It is perhaps not all that surprising that the Öko-Institut was founded in the same year as the decision on Wyhl. The institute was founded in the town of Freiberg by 1500 scientists who "sought to 'objectify' (*versachlichen*) the nuclear debate and to provide local citizen initiatives with expert support in legal proceedings"

[208] The injunction against the planned NPP at Brokdorf was linked to "unresolved problems of storage and radioactive waste disposal." Waste issues were also raised in the court case against Kalkar (Renn and Marshall 2016).

(Joppke 1993: 126). Environmental think tanks like the Öko-Institut came to play an important role in influencing decision-makers at pivotal moments in the German nuclear debate.

As a result of these organized efforts to stymie the growth of the German nuclear program, by 1985, Germany had only built a third of the capacity proposed in the 1973 energy program (Joppke 1990). Even before Chernobyl, plans for nuclear plants were being cancelled as a result of the country's stagnating energy demand (ibid.). The 1986 nuclear accident at Chernobyl served to mobilize and reinvigorate calls for action on the nuclear file. The public wanted nuclear expansion in the country to come to an immediate halt, with a growing number of Germans calling for an immediate phase out of the technology. Opposition to nuclear power had shifted from the political fringes to the mainstream, with opposition to nuclear power at well over 70 percent by 1986 (Hatch 1991).[209]

By the end of the 1980s Germany had cancelled a planned reprocessing plant at Wackersdorf, abandoned a completed but never started fast breeder reactor at Kalkar, and all but discarded the idea of building new reactors in Germany. While political efforts to advance a nuclear moratorium had failed initially to yield results in the *Bundestag* (the German Parliament), a de facto one had taken effect. No new reactors were ordered after 1975, with the last unit being connected to the grid in 1989 (Mez 2009).

From 1968 to 1989, Germany had built a fleet of 19 reactors, which accounted for just over 24 000MW of nuclear capacity, or roughly 30 percent of the country's total

[209] In the immediate aftermath of Chernobyl, 83 percent of the public opposed the construction of additional nuclear power plants in Germany (Joppke 1990).

electricity generating capacity (Mez 2009; Rüdig 2000). Germany had built a relatively large commercial nuclear program that now seemed to be under intense scrutiny both socially and politically. Political talk of phase out had entered the mainstream of German politics by the 1990s with both the Greens and the Social Democratic Party (SPD)[210] advocating for a nuclear exit (*Atomausstieg*). When they formed government in 1998, the question had ceased to be if the phase out would happen but when.

The German Electricity Market

The German electricity market consisted of hundreds of public/private ownership utilities at the state and municipal level prior to market liberalization in the late 1990s, however three major utilities accounted for 65 percent of electricity sales (Eberlein and Doern 2009). Efforts were made to make the electricity market more competitive through legislative changes from 1998 through 2005. The German Government sought to unbundle the large vertically integrated utility companies, forcing them to sell off their stakes in transmission networks and electrical grids. These changes were meant to open up the cartel-like German electricity market to greater competition by allowing smaller utilities to have greater access to the grid (Theobald 2009). Unfortunately, these changes did little to break up the monopolistic utilities who continued to dominate the market.

Following a series of mergers in the early 2000s, four major utilities emerged; Energy On (E.ON), Rheinisch-Westfälische Elektrizitätswerke (RWE), Energie Baden-Württemberg AG (EnBW), and Vattenfall. Together they controlled approximately 80 percent of the country's electricity generating capacity (Theobald 2009; Buchan 2012). These four companies owned all 19 of Germany's commercial NPPs. Only eight remain

[210] In German SPD refers to the: *Sozialdemokratische Partei Deutschlands*.

in operation today. The Swedish utility, Vattenfall, no longer has any plants in operation Germany, however continues to operate seven units in Sweden at Ringhals and Forsmark (WNA 2017e).

Table 5: Germany' Operating Nuclear Fleet (as of 27 June 2017)

Name	**Utility**	**Supplier**	**Type/Output**	**Construction Began**	**Commercial Operation Began**	**Planned Shutdown**
Gundremmingen B	RWE	KWU	BWR/ 1284MWe	1976	1984	2017[211]
Gundremmingen C	RWE	KWU	BWR/ 1288MWe	1976	1985	2021
Grohnde	E.ON	KWU	PWR/ 1360MWe	1976	1985	2021
Phillipsburg 2	EnBW	KWU	PWR/ 1392MWe	1977	1985	2019
Brokdorf	E.ON	KWU	PWR/ 1370MWe	1976	1986	2021
Isar 2	E.ON	KWU	PWR/ 1400MWe	1982	1988	2022
Emsland	RWE	KWU	PWR/ 1329MWe	1982	1988	2022
Neckarwestheim 2	EnBW	KWU	PWR/ 1305MWe	1982	1989	2022

Key Stakeholders and the Decision-Making Process

As we saw in the Finnish and Canadian cases, the decision-making process involves a variety of stakeholders, with diverse interests that can serve to facilitate or frustrate the process at multiple junctures along the way. Germany is on the surface not all that different, however, it does have its own peculiarities that require a more detailed examination.

[211] Gundremmingen B is scheduled to be taken offline in December 2017.

Government

The Federal Government has always exerted considerable power in the area of nuclear power and energy policy in general. Until 1986, the Ministry of Research and Technology (BMFT) was the federal ministry responsible for energy policy related to nuclear power. Following the Chernobyl accident, it was moved to the Ministry for the Environment and Reactor Safety (BMU), now known as Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).[212] The BMFT in collaboration with the nuclear industry was able to operate with considerable freedom in the early years of the German nuclear program, pursuing their policies unimpeded by public opposition to the technology (Hatch 1986; Mez 2009). Germany's strong federal policy in the area of energy policy was bolstered by the consensus that existed amongst all the major political parties in the German *Bundestag* in support of nuclear power (Hake et al. 2015). Today the BMUB, in conjunction with the Federal Cabinet can be seen as the drivers of German energy policy including recent decisions surrounding the nuclear phase out, and the rapid development of renewable sources of electricity.

Industry

In Germany, the term industry can refer to the utilities that operate the reactors as well as the engineering firms that design and build the technology. Historically, Siemens-KWU played a large role in the development of nuclear power in Germany. Siemens-KWU was responsible for building all 19 of Germany's reactors, and the export of reactors to countries like Austria, Brazil, Spain, Switzerland, and Iran. During the late

[212] The name was changed from BMU to BMUB in 2013 (BMUB 2015). The Federal Ministry of the Interior (BMI) had also historically played a role in nuclear regulation. This role has since been taken over by the BMUB.

1980s, Siemens began work with the French nuclear giant Framatome (now Areva) to develop the next generation reactor, the EPR, for global export. In 2001, Siemens took on a 34 percent stake in the newly formed Areva (Fuhrmans 2011).

By 2009 Siemens had opted to leave the Areva consortium to pursue new business opportunities in the nuclear industry. However, by September 2011, following the Fukushima accident and the nuclear phase out decision in Germany, Siemens decided to shutter its nuclear division, opting to focus on conventional thermal power plants and renewable technology (BBC 2011).

As noted above, there are four nuclear operators responsible for running Germany's nuclear fleet: E.ON, RWE, EnBW, and Vattenfall. In this chapter, they are the primary focus of discussion.

Regulatory Authorities and Expert Commissions

The Federal Government is responsible for establishing the framework through which the state authorities licence a nuclear facility. The *1959 Atomic Energy Act* (AEA) serves as the key piece of legislation that sets out how nuclear power is managed in Germany. The BMUB is the responsible ministry at the federal level,[213] supported by the Federal Office for Radiation Protection (BfS) that provides technical and scientific support in regulatory matters. Until July 30, 2016 the BfS had the added responsibility for the construction, management, and operation of German nuclear waste facilities (WNA 2017e). This responsibility has since been transferred to the newly formed Federal Company for Radioactive Waste Disposal (BGE), a federally-owned state corporation

[213] In the past, while Land authorities licensed new reactors, it still required support from the BMI (Hatch 1986).

that falls under the supervision of the BMUB. Additional technical support is provided to the BMUB by a series of advisory committees including the Reactor Safety Commission (RSK) and the Commission on Radiological Protection (ESK) among others (IAEA 2016b).

The RSK is the federal regulator charged with reviewing the safety of German NPPs (WNA 2017e). There are licensing authorities at the *Land* (state) level to implement federal nuclear regulations. Unlike Finland and Canada, there is no unified federal regulator; instead there is a division of labour between a series of federal authorities and those of the *Länder*.[214]

Another body to consider in the German context are the expert commissions that have been called upon at critical junctures (at the behest of the German Government) to help resolve nuclear/energy related issues. They have served like Royal Commissions in the Canadian context. They are meant to provide recommendations to the Government on how to respond to difficult questions of public policy. In this chapter, five examples of these commissions are explored, including: the Gorleben International Review, the 1979/1980 Enquete Commission on the Future of Nuclear Energy, the 2011 Ethics Commission, the Commission on the Storage of High-Level Radioactive Waste (HLWC), and the Commission on the Review of Funding for the Phase-Out of Nuclear Energy (KFK).

[214] This chapter focusses mostly on the RSK's safety review of Germany NPPs in the aftermath of the Fukushima accident. That being said, it is worth noting that there is complexity to the German regulatory regime that is not captured in this brief overview. For a good overview of the many federal and state-level regulatory bodies in Germany, see: (IAEA 2016b).

Expert commissions as well as advisory committees like the RSK have come to include participants that are both in favour of and opposed to nuclear power. Groups like the Öko-Institut have been well-represented in these types of commissions. Traditionally, experts from anti-nuclear think tanks like the Öko-Institut have provided well-informed technical and political positions to counter pro-nuclear industry insiders (M. Sailer pers. comm.; Joppke 1993). There has been a concerted effort to bring alternative voices into the decision-making apparatus in Germany to better reflect the divisions that exist within the broader German society. I would argue that this is a unique feature of the German process not seen in Canada or Finland.

Environmental Groups

Environmental groups and civil society have played a critical role in shaping the nuclear discussion in Germany. It began with protests at proposed nuclear sites in the 1970s and from there grew into an extremely successful political movement. While the emphasis of this chapter is on the political elements of the green movement, namely the advent of the Green Party (*Die Grünen*) and their success in advancing the nuclear phase out, the role of grassroots movements like the BBU (the Federal Association of Citizen Initiatives for Environmental Protection), the BUND (Federal Council for Environmental Protection),[215] and Greenpeace are undeniable. The strength of German protest culture, in conjunction with the development of the political wing of the green movement and their shared "uncompromising rejection of nuclear power", played a pivotal role in advancing

[215] BUND is the German wing of the international NGO, Friends of the Earth. BUND is the largest environmental organization in Germany with 480 000 members (Hasegawa 2015). By contrast the World Wildlife Federation (WWF) and Greenpeace, two of the larger green groups in Germany, only have roughly 200 000 members each (ibid).

the nuclear phase out in Germany (Hatch 1995: 425). Part of their success can be attributed to a strong communications campaign, aided by a good relationship with the media, where they are seen as "respected and trusted sources of information" (Vasi 2011: 68).

In addition to the grassroots environmental movement and the Green party, there is also a strong tradition of environmental think tanks which have served to provide counter-expertise, as well as academic rigour, and legitimacy to the anti-nuclear movement. One of the earliest examples of this noted above was the Öko-Institut founded in 1977, and the Wuppertal Institute for Climate, Environment and Energy founded in 1991, among many others. They worked to challenge claims from industry and government that Germany required nuclear power for economic growth, suggesting alternative energy policies that focused on conservation and emerging renewable technologies (Joppke 1993; Vasi 2011; Hasegawa 2015). Their inclusion into the regulatory process as experts on nuclear commissions added legitimacy to their position in society, and made them a powerful voice in the German nuclear debate.

The Public

The public is included in the decision-making process through the licensing process, as it is in Finland and Canada. Public hearings are a requirement of the licensing process for construction licences (i.e. for new repositories, NPPs, etc.). A decision by the state-level authority regarding the construction of a new facility would follow the public hearings, and consultations with advisory committees (Hatch 1986).

In the case of Germany, the public has been quite influential in shifting the political discussion on nuclear energy, given its willingness to participate in large anti-

nuclear demonstrations and the prominence of the issue at the ballot-box for the last twenty-plus years. An all-party political consensus on the issue of nuclear power gradually became a wedge issue for the Greens and the SPD. This political strategy proved effective at least in part as a result of the sea change in public opinion on the issue.

Prior to the 1973 Energy Crisis, nuclear power did not register as a major political issue in Germany (Hatch 1986; 1991). Ion Vasi (2011) notes that while the majority of Germans supported nuclear power during the 1970s, by the late 1980s the pendulum had swung in the other direction. The protests that took place at Wyhl, Baden-Wuerttemberg in 1975, marked the beginning of the public's engagement on the nuclear issue. In addition to large-scale demonstrations and public petitions, polling began to show a tangible shift in the public's thinking on nuclear power. By the late 1980s the public was firmly against the construction of new reactors (Hatch 1991). Following the Fukushima accident and the Merkel Government's decision to expedite the phase out, public support has not wavered. 73 percent of Germans continue to support the government plan to shut down the country's eight remaining reactors by 2022 (WNA 2017e). Sustained engagement on this issue over the last 40 years has ensured that the public has a strong indirect role in decision making process regarding nuclear power in Germany.

Academia

Academia plays an indirect role in the decision-making process in Germany. They play a pivotal role when it comes to innovation within the field, including but not limited to: designing the next generation of reactors, solving problems in existing NPPs, and studying different ways of handling nuclear waste. In the German context, they also play

a role in regulatory and advisory committees, as well as contributing to the public debate over the future of nuclear power.

In this chapter, academia refers to the technical experts from the faculties of science and engineering, as well as the social scientists, that have played a role in shaping the public's views on nuclear power. Examples would include participation on technical advisory committees like the RSK and the 2011 Ethics Commission. Often this engagement has also included media events like the 9-hour televised debate on April 28, 2011, that included political scientists like Miranda Schreurs, alongside sociologists like the late Ulrich Beck, and politicians like Klaus Töpfer, discussing the future of Germany's energy system (Hasegawa 2015; Schreurs pers. comm.).[216]

This section has outlined some of the key players involved in the broader decision-making process as it relates to German energy policy. In the case of Finland and Canada, we saw how a decision regarding a nuclear reactor could always be delayed, reversed, and was rarely ever final. Similarly, the decision to adopt a nuclear phase out in Germany was gradual, vigorously contested, and far from certain. German political parties slowly shifted their views on nuclear power from an initial consensus on the importance of nuclear power (for energy security), to calls for its immediate phase out. This next section explores how these policy positions emerged, evolved over time, and eventually served to reshape Germany's energy future.

[216] Schreurs (pers. comm.) noted that this televised debate had between 1 and 2 million viewers, representing a relatively a high-level of engagement on the nuclear debate.

Early Political Responses: From Moratorium to Phase Out

Following the large-scale anti-nuclear protests of the 1970s, political calls for an end to the use of nuclear power began to emerge, but they lacked a political champion at the federal level.[217] At the time, the three major political parties with representation in the *Bundestag* "retained their generally positive attitudes toward nuclear energy" (Hake et al. 2015: 534).

In 1977 Chancellor Helmut Schmidt's SPD and their coalition partners the Free Democratic Party (FDP) flirted with the idea of a nuclear moratorium in their platform, but failed to endorse one. The nuclear industry successfully countered this line of thinking by presenting nuclear expansion as integral to economic growth in Germany. The nuclear conglomerate KWU made the case to the Federal Government that a moratorium would lead to reduced economic growth, a loss of over 1.6 million jobs in West Germany, and energy insecurity throughout the country (Hatch 1991: 79).[218] At the time, KWU's operations were being challenged by court injunctions linked to siting and waste issues as a result of a growing anti-nuclear movement.[219]

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[217] In the state of North-Rhine Westphalia, the state government implemented a five-year moratorium on licences for new nuclear sites (Dyson 1982). Much of the discontent at the time had to do with a fast breeder reactor under construction at Kalkar. States like North-Rhine Westphalia and Hesse responded to the nuclear issue much earlier than the Federal Government in Germany.

[218] KWU sent a memorandum to all levels of the German Government making the case that up 1.6 million jobs would be lost (direct and indirect) by the year 1985 as a result of the proposed moratorium in 1977. KWU anticipated 260 000 jobs would be lost in the nuclear industry as a result of the expected loss of contracts at home and abroad (Hatch 1986).

[219] The administrative courts were not allowing construction licences to be issued unless there was a long term waste plan in place. No long-term waste facility or reprocessing centre had been built or sited at the time. Notably, waste was cited as an issue in the cases against Brokdorf and Kalkar (Renn and Marshall 2016).

The injunctions imposed by the administrative courts had cost the industry 1.6 billion deutsche marks due to lost orders, and upwards of 20 000 jobs in 1977 alone (Dyson 1982). KWU and the utility companies desperately needed an ally in the Federal Government. There was concern that their multi-billion-dollar business at home and abroad was at risk of being irreparably harmed by the specter of a formal nuclear moratorium looming over West German politics.[220] Industry lobbyists and organized labour fought to keep a nuclear moratorium from being endorsed at the FDP and SPD party conventions in 1977. As a result of these efforts, the SPD-FDP Government (1977-1982) adopted a compromise on the nuclear issue. They endorsed a policy that favoured a reduction in the domestic growth of nuclear energy "to the extent absolutely necessary to secure electricity supply" (Hatch 1991: 81). This would allow existing projects to proceed unhindered, while attempting to appease those concerned with the rapid growth of Germany's nuclear power program. [221]

It was becoming increasingly apparent that the energy consensus that had dominated the early years of Germany's nuclear development was beginning to unravel.

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[220] KWU secured sales of reactors to Brazil, Iran, and Argentina. Given the lack of domestic orders post-1975, these exports were of critical importance to the German nuclear industry. "Without the foreign orders received by KWU in 1975 from Brazil and in 1976 for two reactors from Iran, the German nuclear industry would have been in great danger of folding" (Hatch 1986: 127).

[221] Renn and Marshall (2016: 227) note that while the anti-nuclear movement was able to use the administrative courts to their advantage early on, that this "had little success in halting nuclear policies or influencing the majority of German people to develop an anti-nuclear attitude." Like Hake et al. (2015), they highlight the political consensus that existed amongst the federal political parties as remaining largely intact until the emergence of the Green Party in 1983 and later the policy reversal of the SPD in 1986. This chapter generally endorses this thesis. The shift in political thinking on the nuclear issue was quite gradual, as evidenced by the consistently pro-nuclear outlook of German governments from the 1955 *Paris Accords* through to 1998.

In response to the growing unrest on the nuclear issue, Chancellor Schmidt called for an *Enquete* Commission in December 1979 to help establish a new political consensus on the future of nuclear power in Germany. It included parliamentarians and experts both in favour and against nuclear power. It was an effort to depoliticize the issue and find common ground for German energy policy moving forward (Joppke 1993).

It explored four different energy scenarios, including two without nuclear energy. They determined that an energy future without nuclear energy was both technically and economically feasible under certain conditions, namely a reduction of energy demand, and the adoption of alternative energy sources (Hake et al. 2015). While not without its challenges, the Enquete Commission's Report "demonstrated that abandoning nuclear power would not [necessarily] impair economic growth and high living standards" (Joppke 1993: 127-128). While no definitive consensus emerged from the commission, they recommended a ten-year moratorium on new nuclear projects (Hatch 1986).[222] This, however, was not enough to shake the political consensus surrounding nuclear power that existed amongst the Federal political parties. That being said, it is credited as a turning point in the political discussion on nuclear power in Germany (Joppke 1993; Mez 2009; Hake et al. 2015).

Christian Joppke (1993: 127) notes that the 1980 Enquete represented a "unique enterprise" whereby, for "the first time, nuclear proponents and opponents jointly searched for a rational procedure by which not only the narrow economic costs and benefits but also the broad societal implications of different energy systems could be

[222] The Enquete Commission's Report was released on June 27, 1980. For a German transcript see: (Deutscher Bundestag 1980).

assessed." It set a precedent that required experts, both those in favour and those opposed to nuclear power, to be represented in future fora of this kind. An industry that had come of age in a relatively closely guarded corporatist decision-making system would now be subject to greater scrutiny from counter expertise emanating from groups like the Öko-Institut. Lutz Mez (2009: 270) highlights the 1980 Enquete and the emergence of the German Green Party as early signs of the "paradigmatic change" taking place in German energy policy at this time.

The Emergence of the Green Party

The perceived failure of the major political parties to respond to the nuclear issue was one of driving forces behind the formation of the Green Party (*Die Grünen*).[223] They first appeared on a national ballot during the 1980 election.[224] While the party campaigned on a diverse set of issues, its anti-nuclear stance was a key plank in its platform (Joppke 1993; Hatch 1986; Rüdig 1990). It is worth noting that in those early years the Greens were campaigning on ecological issues, as well as those emerging from the peace movement. This included barring nuclear-armed Cruise and Pershing missiles from being stationed in West Germany (Edwards 1998).[225] The Greens also called for the abolition of the North Atlantic Treaty Organization (NATO) and the Warsaw Pact as part of a broader pacifist agenda.[226] At the time, they failed to garner sufficient support for

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[223] In 1993 the German Green Party merged with the former East German party known as Alliance 90 (*Bündnis 90*). The party is now known as *Bündnis 90/Die Grünen.*

[224] Green candidates had participated in state-level elections as early 1977 but a national party was not formed until January 13, 1980 (Frankland 1995). The federal election was held later that year on October 5, 1980.

[225] In 1982, they secured 4 million signatures as part of a petition to have the American intermediate-range nuclear missiles (INF) removed from Germany (ibid).

[226] Their views on US missiles deployment and nuclear power allowed the Greens to begin to peel away voters from the SPD, particularly among the left-leaning youth wing

representation in the Bundestag, but their message had begun to filter its way through mainstream German politics.

Going into the 1983 election, their party platform advocated an immediate phase-out and "dismantling" of the country's NPPs (Edwards 1988). In just their second national election they were able to garner the votes necessary to enter the *Bundestag* with 5.6 percent of the popular vote in 1983 (Hatch 1991). This was a significant achievement given that the *Bundestag* had been dominated by three major parties (the CDU/CSU,[227] FDP, and SPD) from 1961-1983, with all other parties failing to gain representation during that period. While the Greens remained a minor party within the *Bundestag*, they managed to achieve some level of influence and power at the state level. In 1985 they joined the governing coalition in Hesse alongside the SPD.

While the Green Party had campaigned on a strong anti-nuclear platform, they struggled to advance that agenda in any meaningful way at the federal or state level. It took until 1984 for the Greens to present a proposal for a nuclear moratorium in the *Bundestag*. Joppke (1990; 1991) suggests that the more ideologically driven elements of the Green Party would have wanted a much stronger phase out proposal, but that the

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of the party (Edwards 1998). The coalition between the peace movement and environmental movement in Germany was referred to by some as the "eco-pax" (Joppke 1993:170). While there were close ties between both movements during the 1980s, "they remained separate organizationally and ideologically" (ibid.).

[227] CDU refers to the Christian Democratic Union Party or in German *Christlich Demokratische Union Deutschlands*. The CSU refers to the Christian Social Union in Bavaria or the *Christlich-Soziale Union in Bayern*. Both parties are Conservative Christian Democratic parties that work together within the *Bundestag*, but the CSU only fields candidates in the state of Bavaria, while the CDU runs candidates in the other German Länder (Edwards 1988).

leadership had prioritized other policy initiatives at the time.[228] They focused their political capital on issues like acid rain and opposition to US nuclear missiles being stationed in West Germany. These issues took precedence over the nuclear power issue.[229]

It is important to note that almost 95 percent of the German Parliament remained relatively pro-nuclear at this time (Hake et al. 2015). The idea of a nuclear moratorium had been debated at political party conferences in the late 1970s but failed to be adopted by the SPD or the FDP. By the 1980s the Greens had emerged as a political force and brought forth a proposal for a nuclear moratorium; however, it remained largely aspirational, and did not enjoy the political support needed to move beyond the back benches of the German Parliament.

Nuclear Waste, Reprocessing, and the Opposition Movement

It is challenging to discuss nuclear power in Germany without giving consideration to how the question of nuclear waste has served to shape the debate, and act as a conduit for opposition to the technology. From the outset, German plans for nuclear power had included reprocessing, fast reactors, and the need for a repository to store the

[228] The anti-nuclear (power) movement had lost momentum from 1982-1984, in large part due to the popularity of the peace movement in Germany. The Chernobyl accident in conjunction with the end of the Cold War helped to refocus the party's efforts on the nuclear phase out, as the peace movement began to wind down (Joppke 1993; Rüdig 1988).

[229] There were internal debates within the party over whether they wanted to remain a protest party or vie to become a coalition partner and enter government. These debates between the Realpolitiker (those who wanted to enter government) and the Fundamentalisten (the ideological purists who saw the party as an extension of the environmental movement), led to tensions over the kinds of policies the party should advocate for in those early years (Edwards 1998; Frankland 1995; Joppke 1993). This often led to inaction and a lack of coordination between the different wings of the party.

vitrified waste (the by-product from the reprocessing process). "Germany's interest in reprocessing was driven by the idea of plutonium breeder reactors and a 'closed-fuel-cycle' in which plutonium would be produced from uranium-238 and recycled as fuel" (Kallenbach-Herbert et al. 2011: 45). As a result, it was a legal requirement under the AEA for spent nuclear fuel to reprocessed.[230] Reprocessing was seen as an important way of limiting waste produced by the German nuclear fleet, and it also served to promote the need for advanced reactor designs like those envisioned at Kalkar.

Initially Germany had planned for the development of a single site, that would host both a reprocessing facility as well as a deep geological repository. The state of Lower Saxony had been selected for its "geologically stable salt formations" (Hatch 1991: 83). At the time they were thought to be ideal rock formation to host a deep geological waste repository.

The site selection process was first initiated by the Federal Government in 1972, however, the Government of Lower Saxony sought to take control of the process in 1976 (Hocke and Renn 2009). This was seen as an effort to delay the selection process and avoid the political violence and disruptions that were experienced at nuclear sites such as Wyhl and Brokdorf (Hatch 1991; Hocke and Renn 2009). In February 1977, Lower Saxony's Government selected Gorleben, a salt dome located approximately 5km from the East German border, as the site to host the national repository and reprocessing facility (Hatch 1991). State officials offered some technical justifications for selecting Gorleben as the site. However, considering the challenging political environment and the potential for public backlash, in hindsight, these justifications appear to have been more

[230] This was a legal requirement from 1979-1994 (Hasegawa 2015; Rüdig 2000).

politically driven (Hocke and Renn 2009). Unlike Canada and Finland, where public consultations were held to find a willing host community, Gorleben was a top-down decision made by the state government. Chancellor Schmidt's SPD-led Government accepted Lower Saxony's decision, but the public proved less enthusiastic.

While Gorleben had initially been chosen by policymakers to minimize the potential for political unrest, its selection failed to have the intended effect. It quickly became a central hub of national protest against Germany's nuclear power program (Hocke and Renn 2009). Protesters came to see Gorleben as a last stand against a rapidly expanding domestic nuclear programme. Wolfgang Rüdig (2000:50) explains: "Gorleben thus came to symbolize the megalomaniac plans of the nuclear industry, envisaging the construction of dozens of further reactors and the preparation of the transition to a plutonium-based 'all-nuclear' energy future." Opposition groups saw it as a way of blocking an "essential [component of] waste management," and as a result limiting the growth of nuclear power in Germany (Blowers and Lowry 1997: 148).

The rise of large scale opposition to the Gorleben site led the Government of Lower Saxony to convene public hearings to discuss the feasibility of the project, and to allow for opponents to have their concerns heard. These hearings were part of an international review of the project, known as the Gorleben International Review. It was headed by Austrian physicist Helmut Hirsch, and 20 experts, many of whom were known to be anti-nuclear (Nelkin and Pollak 1982).[231]

[231] This included among others, the world-renowned American environmentalist, Amory Lovins.

In the lead up to the hearings, the United States experienced a partial-meltdown of unit 2 at the Three Mile Island nuclear power plant on March 28, 1979.[232] In response, a demonstration was held in Hannover to protest the Three Mile Island accident and Germany's nuclear power programme, including Gorleben. Over 100 000 people marched in the Hannover demonstration, one of the largest the country had ever witnessed (Nelkin and Pollak 1982).

Six days of public hearings were held to evaluate Gorleben (from March 28 to April 3 1979) in Hannover, the capital of Lower Saxony. The hearings bracketed the question of Three-Mile Island and "purposely restricted the issue under investigation: [to] the safety of the *Entsorgungszentrum*" (Hatch 1986: 114).[233] This was a major media event that was attended by the public and the Prime Minister of Lower Saxony Ernst Albrecht. Following the hearings, it was determined by the Government of Lower Saxony that, while the project was technically feasible, public resistance made the proposed integrated facility at Gorleben politically impossible (Hocke and Kallenbach-Herbert 2015). At the time, Chancellor Schmidt noted that "while it is too soon to write an obituary for the death of nuclear power, criticism has become respectable" (quoted in Nelkin and Pollak 1982: 181). Prime Minister Albrecht acknowledged that while the project was safe from a technical perspective (Hatch 1986), his government had "failed to convince the public of its necessity and safety" (quoted in Nelkin and Pollak 1982: 181). Dorothy Nelkin and Michael Pollak (1981) assert that the demonstrations held in Hannover in the wake of the Three-Mile Island accident played a pivotal role in forcing

[232] For a brief explanation of the accident see: (US NRC 2014).
[233] The integrated nuclear waste management center was referred to in German as a *Nukleares Entsorgungszentrum* or NEZ (Hocke and Renn 2009).

the Albrecht Government's hand on Gorleben.[234] While the accident had not been the root cause of opposition to nuclear power in Germany, or the nuclear waste facility planned for Gorleben, it fed into a growing discontent with the government's approach to technology management and a perceived lack of consultation with affected communities.

The political rejection of the integrated waste facility by the government of Lower Saxony led the federal government to pursue a reprocessing facility in Bavaria at Wackersdorf, while maintaining the option for a final repository and interim storage facility at Gorleben. This was yet another setback for the country's nuclear program whose expansion was already being stalled by the administrative courts.

A Political Shift in the German Energy Debate

Following the defeat of Helmut Schmidt's SPD Government in October 1982, the Social Democrats began to take on an increasingly anti-nuclear stance (Joppke 1990; Hatch 1991; Koopmans and Duyvendak 1995). The SPDs had fought costly internal battles over the issue and had begun to lose supporters to the Green Party. As result, they began to change their tone on the nuclear issue. They began by declaring their opposition to a proposed reprocessing plant at Wackersdorf, Bavaria in 1984 and a fast reactor at Kalkar, North-Rhine Westphalia (Koopmans and Duyvendak 1995; Joppke 1993). These sites had come to be lightning rods of conflict for the anti-nuclear movement in the lead

[234] It is worth noting that the protest had been planned in advance of the accident. It ultimately proved to be much larger than what had been anticipated by its organizers, having taken place in the immediate aftermath of the Three Mile Island accident. A German diplomatic cable at the time noted: "it is not clear to what extent Harrisburg encouraged additional participation, but it will undoubtedly be a strong asset for environmentalists in spreading their anti-nuclear message" (US Department of State 1979).

up to Chernobyl. These protests were increasingly turning violent, with police using tear gas and other tactics in an attempt to clear the sites (Joppke 1990).[235]

Following the Chernobyl nuclear accident in Ukraine on April 26, 1986, the SPD joined the Greens in their call for a nuclear phase out (Koopmans and Duyvendak 1995; Rüdig 1990). While the Greens at the federal level were calling for an immediate phase out of nuclear power, the SPD had a slightly more nuanced position. They called for a phase out to take place over the next decade to avoid any large increases in electricity costs and to limit any potential damage to the German economy (Hatch 1991). At their party convention in August 1986, the SPD formally adopted a ten-year phase out plan and renewed their call for the cancellation of the fast breeder reactor at Kalkar and the planned reprocessing plant at Wackersdorf (Joppke 1993). This was seen as a big shift in German politics; a major political party at the federal level was committing itself to ending the use of commercial nuclear power and calling for a transition to alternative energy sources. The SPD's political reversal had come to be seen as necessary following the Chernobyl accident.

Opinion polls conducted by the Survey Research Institute following the accident suggested that upwards of 80 percent of Germans were opposed to the idea of building new reactors (Joppke 1993). By contrast the public had been almost evenly split on the issue when the SPD had left office in 1982 (ibid).[236] In light of the public's increasingly

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[235] To give some perspective on the size of these demonstrations; in the case of Wackersdorf, there had been an 80 000-person demonstration a month prior to the Chernobyl accident (Joppke 1990).

[236] The survey was commissioned by the German newspaper *Der Spiegel*. In March 1982, 52 percent of Germans favored new construction of NPPs while 46 percent were opposed. By August 1986 80 percent opposed new construction, with only 18 percent still in favour (Joppke 1993: 180).

hostile view of nuclear energy, the SPD's shift in energy policy can be seen as politically astute following the Chernobyl accident. This reversal on nuclear energy policy was not without an element of irony given that the SPD had for the previous decade promoted nuclear power "as a key industry for [the] modernisation of the economy…reflected in the priority that it received from successive ministers of the…Federal Ministry of Research and Technology…as well as from Chancellor Schmidt [directly]" (Dyson 1982: 27).[237] As late as 1982, the Schmidt Government had been working to streamline nuclear licensing to help restart projects stalled by the administrative courts at Grohnde, Brokdorf, and Wyhl, as well as fast-track future new builds (Hatch 1991).[238] Within four years, the SPD had reversed this long-held position abruptly following the Chernobyl accident. This policy change was viewed by some as opportunistic and politically craven as opposed to morally principled (Joppke 1990; 1993).

By contrast, Helmut Kohl's Government (CDU/CSU-FDP) continued to support the nuclear industry, including controversial elements like the reprocessing plant and fast reactor program. Amidst the political and public backlash to nuclear power in the months following the accident, Kohl's Government made a concerted effort to demonstrate competence on the nuclear file. On June 6, 1986, nuclear power was moved from the BMFT[239] to the newly minted BMU. The creation of the BMU was an effort to address

[237] The Ministry of Research and Technology was the federal ministry responsible for nuclear power until 1986, when it was moved to the newly formed BMU.
[238] The Schmidt Government worked with state governments to help expedite the reactor licensing process, to keep their energy policy on track and to avoid the delays that had plagued projects in the 1970s (Renn and Marshall 2016).
[239] BMFT was the acronym for the *Bundesministerium für Forschung und Technologie*. It has since been merged into the Federal Ministry for Education and Research (BMBF) or the *Bundesministerium für Bildung und Forschung*.

concerns over both the environment and nuclear safety emanating from the political left at that time.

Critics of Kohl's policies note that these changes were largely superficial and that "the paradigm of necessity of nuclear power was not [seriously] questioned by the governing parties CDU/CSU and FDP" (Hake et al. 2015: 536). At the time of the Chernobyl accident, West Germany produced approximately 36 percent of its electricity from 19 reactors (Joppke 1990). The Kohl Government still linked nuclear power to economic growth and suggested that a politically imposed moratorium or phase out would seriously harm the German economy. Walter Wallman, Kohl's first Minister of the Environment and Reactor Safety, discounted the idea of a nuclear moratorium as "not even thinkable" (quoted in Joppke 1993: 251). Instead, the Kohl Government tried to reassure the public that there were significant differences between Soviet reactor designs and those found in Germany; moreover, German safety standards were far superior to those found in Ukraine (Schreurs pers. comm.). It was important to distance the German experience from the Chernobyl accident, and to make clear that "such an accident…was not possible in [Western] Europe" where higher standards of safety were adhered to (Schreurs 2013: 91). The creation of the BMU was meant to reassure the public that additional precautions were being taken to maintain a high level of safety.

A Stalled Industry and the Kohl Government's Gradual Reappraisal of Nuclear Power

Chernobyl had come at a time when the utilities were already reassessing the need for new reactors and fuel cycle technologies. Prior to Chernobyl, regulatory delays, high capital costs, and slower than expected growth in electricity demand were limiting the need for new reactors. Nine units had already been cancelled prior to the accident

(Joppke 1990). Within a few short years Germany had gone from a country with ambitious plans to close their fuel-cycle, using some of the world's most advanced reactor designs, to one politically struggling to maintain their fleet of light-water reactors. Exotic designs like the fast reactor at Kalkar and the high-temperature reactor at Hamm-Uentrop were shut down in the years immediately following the Chernobyl accident.[240] The much-maligned reprocessing plant at Wackersdorf was cancelled in favour of reprocessing fuel abroad, in the UK and France. The decision to cancel the reprocessing plant was seen as a concession to political opponents that had long campaigned against the project in "an apparent attempt to shield the existing light-water program from further attacks" (Joppke 1993: 188).

Nuclear power had ceased to be the technology of the future, and now was being characterized by politicians of all stripes as a bridge technology. It was to be used only until new sources of energy could be developed. Klaus Töpfer, Kohl's Environment Minister from 1987 to 1994, openly mused about an energy mix that no longer required nuclear power (Hatch 1991; Joppke 1993). While the Kohl Government was not advocating for a moratorium on new builds, they knew that it would require political support from a public that remained extremely hostile to the technology (Hake et al. 2015). No new reactor had been ordered in Germany since 1975, with the last unit coming online in 1989. By the end of the decade, it was becoming politically unthinkable to support new reactors in Germany.[241]

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[240] Kalkar's SNR-300 was completed in 1985 but never received a licence to operate and was formally cancelled in 1991. The thorium high-temperature reactor (THTR-300) in Hamm-Uentrop operated from 1983 to 1989.

[241] Alexander Glaser (2012) has suggested that by the 1990s there was already a de facto moratorium on new construction and that there was no serious consideration of building

The nuclear industry in West Germany received some reprieve following reunification in 1990. Media reports surrounding the poor safety standards at Soviet-controlled NPPs in East Germany provided a degree of vindication to West German operators that their reactors were indeed far safer and better maintained. Joppke (1993: 189) notes that "compared with the shocking condition of the Soviet-designed East German nuclear plants, the West German plants now [shone] like marvels of safety and reliability." Following German reunification, only Western built reactors remained in service.[242]

Following the Chernobyl accident, the Kohl Government began to emphasize the role that nuclear power could play in reducing emissions in the fight against climate change. While all major political parties in Germany had become responsive to the issue of climate change, nuclear power remained offside for the SPD and Greens (Hake et al. 2015).[243]

The Red-Green Coalition and the First Phase Out

The October 1998 elections marked a significant turn in German politics. Gerhard Schröder's Social Democrats in coalition with the Greens were able to defeat the Kohl

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new reactors by that time. Glaser (2012: 17) asserts that, "no one, including the parties opposed to a phase-out seriously entertained the idea of new reactor construction in Germany, in spite of growing concerns about climate change."

[242] The four units at Greifswald which had accounted for 10 percent of East Germany's electricity supply were shutdown following reunification, and four units under construction were cancelled (Joppke 1993).

[243] Hatch (1995) notes that all major parties were somewhat slow to respond to the issue of climate change. The divisiveness of the nuclear issue in conjunction with the power of the coal lobby had made progress on the issue challenging. In the case of the Greens, it is interesting to note that at the time, "they were less inclined to give much credence to claims about global warming, especially since those claims were often associated with justifications for nuclear power" (Hatch 1995: 425).

Government, which had been in power since 1982. As noted in the previous section, the Kohl Government had been largely supportive of the nuclear industry during their time in office, while the SPDs and Greens had actively pushed for a moratorium/phase out. Following the 1998 election, one of the central tenets of the SPD-Green Coalition (also known as Red-Green Coalition) was to negotiate the terms of a nuclear phase-out (Rüdig 2000).[244] For the Greens, there would be some challenges translating the politics of opposition to sound government policy.[245]

The Green Party had included in its platform plans to enact an immediate nuclear phase out, end shipments of fuel for reprocessing, and close existing waste sites in Germany with no compensation for the utility companies. By contrast, Chancellor Schröder wanted a negotiated agreement with industry to avoid litigating compensation claims with utilities through the courts over the forced closure of their plants. Following the election, it became clear to the SPD-Green leadership that they would need to create "a realistic phasing out policy that was going to be legally and constitutionally sound" (Rüdig 2000: 55). The Schröder Government initially committed themselves to amending the AEA within their first 100 days in office. These amendments would ban the export of

[244] It is worth noting that an entire chapter of their coalition agreement was dedicated to the issue of the nuclear phase out (Mez and Piening 2006).

[245] The Green Party had difficulty quelling internal unrest within the party following the election. A stark divide existed between the more ideologically oriented elements of the party who insisted on an immediate phase out and those wishing to form government and negotiate a deal with the nuclear industry. The more radical wing of the party campaigned on a slogan of "consensus is nonsense" rejecting the idea of sitting down with the utilities to negotiate the terms of a phase out (Rüdig 2000: 57). Ultimately the party leadership interested in forming Government with the SPD, led by Joschka Fischer, endorsed the coalition agreement and succeeded in getting the majority of the party to ratify it, pushing these opposition elements largely out of the party. These compromises served to alienate elements of their political base that had their roots in the anti-nuclear movement (Poguntke 2001).

fuel for reprocessing, and increase the safety of existing NPPs in Germany. This would be followed by up to a year of negotiations with industry to secure a smooth phase out of nuclear power (Rüdig 2000). There was interest on both sides to get a deal done.

For industry, a negotiated phase out would provide greater certainty for their investors that their plants could operate securely for a fixed period of time. By contrast, for the Schröder Government, it would allow them to make good on a key election promise, and avoid potentially costly legal battles with the nuclear operators for compensation resulting from the forced shut downs of their plants. At the time, there were 19 reactors operating at 14 sites, producing roughly 30 percent of the country's electricity (Mez and Piening 2006). Even a well-planned phase out would take decades to implement given the lengthy process associated with decommissioning and dismantling a reactor. The talks would be limited to a relatively small circle of high-level government officials, and representatives from the big four utility companies. Government officials included Chancellor Schröder, his Minister of Economic Affairs, Werner Müller, and the country's first Green Minister of the Environment, Jürgen Trittin. The utilities were represented by the largest nuclear operators at that time: RWE, EnBW, VEBA, and VIAG.[246]

A key part of these talks would center on determining how long utility companies would be able to operate their reactors for (Mez and Piening 2006). German nuclear operators at that time were granted licences that did not explicitly limit how long a reactor could operate for; the negotiated phase out sought to impose such a limit. The

[246] VIAG and VEBA merged to become E.ON in 2000. They became the largest nuclear operator in Germany, with an ownership stake in 12 of the country's 19 reactors (WNA 2017e).

Green Party had initially pursued a number of concessions from industry, including an immediate ban on reprocessing, an increase in liability coverage in the event of an accident, and a 25-year limit on reactor licences.[247] By contrast, industry sought licences that would allow their plants to operate for 35 years, a standard more in line with their American counterparts (Mez and Piening 2006).[248] Both sides fought over whether licences would be based on calendar years or whether they would be linked to the amount of electricity produced. This proved to be a significant point of friction within the negotiations because a strict calendar interpretation would further limit how long the utilities could operate their plants for.

Throughout the negotiations, the Green Party vehemently opposed the 35-year proposal advanced by industry. The Greens desperately wanted to demonstrate tangible results to their supporters during their first term in office. The goal was for at least one reactor to go offline ahead of the 2002 elections (Rüdig 2000).

Initially there was no consensus within the Red-Green Coalition on what the Government position should be regarding operating licences. In November 1999, the Cabinet agreed to a '30+3' compromise, which allowed for 30-year operating licences, plus a 3-year transition, before the agreement took effect in order to avoid the immediate shut down of Germany's oldest NPPs (Rüdig 2000). Even though there had been some compromise on the part of government, industry was still unwilling to accede to the '30+3' proposal. The issue over operating licences persisted until the last day of

[247] The Greens had long sought to end the reprocessing of nuclear fuel, with a preference for geological disposal.
[248] The nuclear industry had initially sought 40-year operating licences, but this was a non-starter with the Schröder Government (WNA 2017e).

negotiations (Mez and Piening 2006). The eventual compromise shifted the discussion away from calendar years of operation to a production limit on electricity.[249] Each German reactor would be permitted to produce up to 2623 TWh over the lifetime of the plant, with the ability to transfer remaining capacity over to newer reactors, serving to extend the life of those plants (Mez and Piening 2006). In practice, this meant that, on average, a plant could operate for up to 32 years.

The talks had begun on January 26, 1999 and concluded successfully on June 14, 2000. A consensus document was produced that outlined the plan for how Government and industry would work together to phase out nuclear power in Germany over the coming decades.[250] The agreement fundamentally transformed the rules of the game for nuclear power in Germany. Aside from placing clear limitations on the future operation of commercial NPPs in Germany, the agreement also signaled to industry that the next amendment to the AEA would include a provision to ban the future construction of new reactors (Agreement between the Federal Government and Utility Companies 2000). The compromise would allow operators to recoup their investment from existing reactors, but limited life extensions of German NPPs to the capacity transfers established in the consensus document. Additionally, the agreement would ensure that utilities relinquished their right to secure compensation through the courts as a result of the phase out (ibid.). Other important concessions surrounding waste management and reprocessing were

[249] Rüdig (2000) notes that another key element of this last minute compromise was a deal on waste shipments which had been under review, preventing essential shipments of spent fuel for reprocessing to France. The deal promised that nuclear operators could resume shipments to and from La Hague, a reprocessing plant in France, through to July 1, 2005.

[250] For an English translation of the consensus document see: (Agreement between the Federal Government and Utility Companies 2000).

agreed to in this document: namely an end to reprocessing abroad by July 1, 2005, a moratorium on work at the planned high-level waste repository at Gorleben, and the creation of on-site interim storage facilities at German NPPs. These changes officially came into effect with the passage of the tenth amendment to the AEA in July 2002. The legislation first introduced in 1959 to regulate the peaceful use of nuclear technology in Germany now sought to end its use based upon the agreed upon framework established in the consensus document (Atomic Energy Act 1959).[251] Germany now joined a small cohort of European countries committed to a future without commercial nuclear power.[252]

While this was a significant victory for the Red-Green Coalition, it did little to bridge the longstanding political divide within the *Bundestag* over the issue of nuclear power. The FDP and CDU/CSU mocked the policy as short-sighted and insisted that they would reverse the decision when they returned to power (Schreurs 2013). The Red-Green Coalition did not survive beyond the 2005 federal election, but their agreed upon framework for the phase out did.[253] During their time in office, Germany's two oldest reactors, Stade and Obrigheim, were taken out of service (Jahn and Korolczuk 2012).[254]

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[251] Section 1 of the legislation outlines the new purpose of the Act, namely: "to phase out the use of nuclear energy for the commercial generation of electricity in [a] controlled manner, and to ensure orderly operation until the date of termination." For an English translation of the legislation, see: (AEA 1959).

[252] Italy, Austria, Denmark and Greece have a ban on the use of commercial nuclear power. Italy closed its last commercial NPP in 1990. They had previously operated four reactors and had two more under construction at the time of their phase out (WNA 2016). In 1978 Austria decided by referendum not to start commercial operation of its only NPP. Denmark and Greece have never operated a commercial NPP but have a ban in place on the use of the technology (Schreurs 2012).

[253] The Red-Green Coalition survived the 2002 elections, but began to lost popularity in 2003 in part due to Germany's economic woes at the time (Mez and Doern 2009).

[254] Stade was shut down in 2003 and Obrigheim closed in 2005. A third plant, Mülheim-Kärlich, began the process of being decommissioned during this period. Mülheim-Kärlich had not operated since 1988 due to a licensing controversy with the state regulator. As

The Phase Out (2005-2009)

From 2005 to 2009, the CDU/CSU-SPD Coalition (also known as the Grand Coalition) remained internally divided over the nuclear issue, but resolved to keep the phase out in place as a point of policy (Mez and Doern 2009). During the 2005 election, Angela Merkel had supported extending the life of Germany's reactors but stopped short of endorsing specific proposals (Mez 2009). Even after forming Government, the nuclear issue remained divisive for Merkel's first cabinet. Michael Glos, the CSU Minister of Economics and Technology (2005-2009), was publicly in favour of nuclear power and proposed extending operating licences to 40 years (Mez and Doern 2009). By contrast, Sigmar Gabriel, the SPD Minister for the Environment, blocked efforts to extend the life of plants slated for closure.

Industry had submitted applications to transfer residual capacity from the now closed Mülheim-Kärlich NPP to Biblis A and Brunsbüttel, but those requests were denied by the BMU (Montel 2007; NEI 2007). Gabriel insisted that these proposed transfers were not in line with the amended AEA, and therefore could not be permitted. He asserted that while the legislation would permit the extension of Germany's newest reactors, it could not be used to surreptitiously keep the country's oldest plants in service (ibid). These proposals were further hampered by high-profile media reports of incidents at Germany's NPPs like the fire at the Krümmel NPP in June 2007. These accidents played into the SPD narrative that nuclear power was a risky technology whose

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part of the consensus agreement, its operator RWE, agreed not to pursue compensation for Mülheim-Kärlich under the understanding that the 107.25 TWh allotted to the plant could be transferred to another NPP (Agreement between the Federal Government and Utility Companies 2000; "Mülheim-Kärlich Plant" RWE n.d.).

usefulness had come and gone. Gabriel quipped at the time that: "German nuclear power plants are the safest worldwide… aside from the occasional explosion or fire" (quoted in Bartsch et al. 2007).[255] Throughout his time in office, Gabriel and the SPD remained vocal opponents of nuclear power and fought to uphold the legacy of the Red-Green Coalition.

At the time, German utilities were holding out hope that the 2009 election could lead to a reversal of fortune, and the return of a pro-nuclear CDU/CSU-FDP Coalition. Merkel was long rumored to be considering a repeal of the phase out if she was able to win a majority government or form a coalition with the FDP (EU Energy 2007).

Phasing Out the Phase Out? (2009-2011)

The Fall 2009 election gave Angela Merkel the electoral support needed to form Government with the FDP. Their coalition agreement highlighted, among other things, their plans to extend the operating licences of Germany's NPPs, but failed to specify for how long, or which reactors this would apply to (Hengst et al. 2009). The newly formed coalition did not seek to rescind the legal prohibition on new builds (ibid).

On September 28, 2010 they adopted the what is known as the *Energy Concept (Energiekonzept)* which outlined a series of guidelines for gradually transitioning Germany away from fossil fuels and nuclear power towards an "age of renewable

[255] To be clear, the fire at Krümmel involved a transformer on site and did not involve the reactor itself. The Brunsbüttel NPP experienced what the operator described as a "network issue" which led to an unplanned outage the same day as the fire at Krümmel. It is thought that the outage at Brunsbüttel could have been one of the causes of the fire at Krümmel (Bartsch et al. 2007; Reuters 2007). It has been noted that that uprates at Krümmel may have also put stress on the transformer which had not been retrofitted to accommodate the increased load (ibid.). Both Krümmel and Brunsbüttel are owned and operated by Vattenfall. Both units remained out of service following these high-profile incidents (WNN 2011).

energy" (BMUB 2010: 3). It outlined an ambitious plan for steep reductions to Germany's emissions. The *Energy Concept* boasted that Germany would "become one of the most energy-efficient and greenest economies in the world while enjoying competitive energy prices and a high level of prosperity" (BMUB 2010: 3). In terms of emissions cuts, the policy document committed Germany to a 40 percent reduction in greenhouse gas emissions (GHGs) by 2020, and a minimum reduction of 80 percent by 2050, using 1990 levels as a baseline.[256] This would require among other things a rapid adoption of renewables. The *Energy Concept* set a high bar, calling for renewables to be ramped up from 14 percent in 2010 to 80 percent by 2050 (BMUB 2010; Bruninx et al. 2013).[257]

To facilitate the transition to a low carbon economy, nuclear power was presented as a "bridging technology" that would help Germany meet these national emissions targets while renewable energy sources (RES) matured and were integrated into Germany's electricity supply mix (BMUB 2010: 3).[258] The Merkel Government made the case that nuclear power could still play a critical role in helping Germany to meet its emissions targets in a cost-effective manner, while ensuring there was adequate security of supply. The Merkel Government made clear that this was a "limited extension" for a

[256] Interim targets include a 55 percent reduction by 2030, and 70 percent by 2040.
[257] The interim targets for renewables were set at 35 percent for 2020, 50 percent by 2030, and 65 percent by 2040. The policy document suggests that these targets are for "gross electricity consumption" as opposed to installed capacity, making these targets that much more ambitious when one considers the low capacity factor often associated with wind and photovoltaics (BMUB 2010: 5).
[258] The idea of nuclear power as a bridge technology was not a new one. The FDP had referred to nuclear power as a "'transitional' energy source" at a party conference back in 1988 (Joppke 1990: 187).

"transitional period" (BMUB 2010: 15). The legislative changes were presented to the *Bundestag* as the eleventh and twelfth amendments to the AEA.[259]

The Government granted 8-year license extensions to reactors built before 1980, and 14-year extensions to those built after 1980. This amounted to an average extension of 12 years to Germany's 17 remaining NPPs. The utilities agreed to a tax being placed on nuclear fuel as a *quid pro quo* for the licence extension. It was believed that utility companies could reap profits of up to €100 billion as a result of the extension. In return for the extension the Government would collect roughly €2.3 billion (or 1.6c/kWh) from the fuel tax through to 2016. Thereafter the fuel tax would decrease to 0.9c/kWh (WNA 2017e).[260] Merkel believed that the fuel tax would make the unpopular decision to extend the life of German reactors more palatable to the electorate, while funding the transition to renewable technology. Merkel wanted to underscore the benefits of using existing nuclear infrastructure to help Germany meet its emissions targets (BMUB 2010). The Merkel Government seemed to be echoing political rhetoric from the Kohl-era following Chernobyl, namely, the idea of nuclear power as a bridge technology to help address climate change in the short term.

It is important to underscore that Germans still had a very negative view of nuclear power. A 2010 Eurobarometer survey found that 52 percent of Germans wanted to reduce their use of nuclear energy, 37 percent supported the status quo, and only 7

[259] The eleventh amendment pertained to the licence extensions. The twelfth amendment related to legislated safety improvements of Germany's NPPs, and issues related to the final waste repository. For a brief overview see, (Schneider 2010).
[260] Industry could seek tax relief in years where they spent €500 million or more on maintenance of a reactor (WNA 2017e).

percent supported increasing its use (Eurobarometer 2010: 26).[261] While a majority of Germans opposed new construction, they remained divided on licence extensions, and suspicious of the arguments being advanced in favour of their continued use. They had low levels of trust in utility companies,[262] a high level of concern over the safety of Germany's NPPs,[263] and a pervasive skepticism that tended to view nuclear power as more of a risk than a benefit.[264] Not surprisingly, the arguments being presented by the Merkel Government in favour of the extensions were not resonating with large segments of the population who remained vehemently opposed to the continued use of nuclear power.

In the lead up to the September 2010 announcement, one poll suggested as many as 56 percent of Germans opposed the idea of life-extensions for Germany's nuclear fleet (Spiegel Online 2010b).[265] Perhaps not surprisingly, the Government decision led to mass protests, with 30 000 to 100 000 marching in Berlin following the announcement on September 18, 2010 (Goebel 2010).[266] The anti-nuclear movement had been on high alert

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[261] This data was collected in 2009 during the federal election when the CDU and FDP were actively campaigning on this issue. The survey was conducted between September 11, 2009 and October 5, 2009.

[262] 60 percent of Germans did not trust companies operating Germany's NPPs (Eurobarometer 2010: 62).

[263] 53 percent of Germans believe the risks of nuclear power are "somewhat underestimated + strongly underestimated" and only 51 percent believed that an NPP could be operated safely (Eurobarometer 2010: 46, 54-55). 52 percent of Germans believed that the nuclear regulator "ensured the safe operation of nuclear power plant(s)" (Eurobarometer 2010: 56-57)

[264] 60 percent of Germans saw nuclear power as more of a risk than a benefit (Eurobarometer 2010: 71). Only 33 percent of German respondents saw nuclear power as more of a benefit than a risk (ibid).

[265] This poll was conducted in August 2010. A July 2010 poll conducted by *Die Zeit* put that number at 49 percent (cited in Schreurs 2012: 35).

[266] Organizers put the number at 100 000, however police suggest that 30 000 to 40 000 took part in the march.

since the 2009 election. This was evidenced by a massive 120 000-person demonstration on April 26, 2010, on the anniversary of the Chernobyl accident protesting the expected lifetime extensions (Schreurs 2012; UPI 2010). Anti-nuclear groups publicly challenged the proposed extensions, using mass demonstrations in an effort to bring attention to the issue.

Politically, the decision was causing ripples, both within the Merkel Coalition and amongst the opposition parties. Internally, the CDU Environment Minister, Norbert Röttgen, had pushed for much shorter extensions of four to eight years, preferring a greater focus on renewables (Spiegel Online 2010b). The leader of the SPD, Sigmar Gabriel, characterized the extensions as a sign that Merkel had succumbed to political pressure from the utilities, and as a result, put public safety at risk (ibid.). Green Party Co-Chair, Jürgen Trittin, echoed this sentiment suggesting that Merkel was beholden to the nuclear lobby and did not "have the support of the majority of the people for its pro-nuclear course" (quoted in Spiegel Online 2010a). Gabriel and Trittin, two former environment ministers, actively campaigned against the licence extensions, and attended major protests in solidarity with the demonstrators (UPI 2010).[267]

Despite the public pressure to reconsider the licence extensions, the amendments to the AEA passed in the Bundestag on October 28, 2010. To avoid being blocked in the Bundesrat, the German upper chamber, which was controlled by the opposition, it was sent to directly the President for his signature (Schreurs 2012).[268] The law came into

[267] Gabriel, was the Minister of the Environment in Merkel's First Cabinet from 2005 to 2009, while Trittin served in the Red-Green Government in this capacity from 1998 to 2005.

[268] This political maneuver was seen by some scholars as unconstitutional (Schreurs 2012).

force on December 8, 2010 (BVerfG 2016b). The Merkel Government had spent considerable political capital on this issue and succeeded in advancing their energy policy, however the victory would prove to be short-lived.

Fukushima and the German Response

On March 11, 2011 a major accident took place at the Fukushima Daiichi Nuclear Plant in Japan. Three units experienced a core meltdown and a fourth suffered significant damage following a major earthquake and tsunami.[269] The accident had a profound effect on Germany. While the Chernobyl accident had been attributed to poor safety standards within the Soviet Union, such an argument could not be advanced in the case of Fukushima. The accident hit close to home given the "cultural proximity" Germans shared with the Japanese (Wittneben 2012: 2). The two countries had often likened themselves to one another in a friendly sort of rivalry. Japan and Germany had both rebuilt themselves following the Second World War, becoming two of the strongest industrialized economies in the world, renowned for their "quality engineering and efficiency" (ibid.). The fact that such a significant nuclear accident had taken place in Japan served to shake public confidence in the notion that NPPs could be operated safely in any country, irrespective of their development and regulatory safety regime (Schreurs pers. comm.). "Fukushima did not change the 'objective' safety status of German reactors, but it did change the perception of nuclear safety on various social levels, even in former pro-nuclear groups" (Hake et al. 2015: 542). The Fukushima accident caused

[269] Richard Samuels (2013) provides a detailed account of the accident and the ramifications for Japan.

the Merkel Government to go into immediate damage control, as they sought to limit the political aftershock in Germany.

The political response was swift. The Fukushima accident had occurred in the early morning hours of Friday March 11, and by midday, it was reported that Chancellor Merkel was consulting with close advisors about the potential for enacting a nuclear moratorium that would put the planned reactor life extensions agreed to in 2010 on hold (Spiegel Online 2011). On Saturday March 12, the Government hosted an emergency meeting to discuss their options. Concerns were raised about how the nuclear issue might hurt the incumbent's (CDU/CSU-FDP coalition) prospects in the forthcoming elections being held in three German states, including Baden Württemberg, a conservative stronghold. The Christian Democrats were perceived to be out of step with the public on the nuclear issue, making it increasingly difficult to convince an uneasy electorate of their ability to address the issue effectively (Keil and Gabriel 2012). By Sunday, a preliminary decision on the future of nuclear power in Germany had been made.

It was announced on Tuesday March 15, 2011, less than a week after the Japanese nuclear accident (Schreurs 2012). As part of her response to Fukushima, Merkel ordered seven of the oldest reactors in the country (all built before 1980), and one reactor that was already offline at the time of the Fukushima accident, to be shut down immediately for a 3-month period to allow the country to assess the safety of commercial NPPs in Germany (Lechtenböhmer and Samadi 2013).[270] Additionally, there would be a moratorium placed

[270] In practice this meant that only 6 operating reactors were shut down as a result of the initial 3-month moratorium. Krümmel and Brunsbüttel were already offline at the time of the Fukushima accident (Lechtenböhmer and Samadi 2013). Krümmel had been offline since July 2009. It had been briefly restarted following the 2007 fire, only to have to be shut down after two weeks of operation. Brunsbüttel had remained offline since 2007.

on the planned lifetime extension of the German nuclear fleet. Neither Three Mile Island, Chernobyl nor Fukushima created the anti-nuclear sentiment in the country, rather they served to reinforce public opposition to the technology and validate their longstanding concerns over its safety. The Merkel Government was trying to get ahead of what could potentially be a very negative electoral cycle for them. They were trying to fend off the opposition, notably the Greens, who seemed far more credible on the nuclear issue following the Fukushima accident.

On March 17, 2011, the *Bundestag* called on the BMU to "conduct a comprehensive review of the safety requirements for the German nuclear power plants…carrying out new risk analysis…with consideration of the knowledge available about the events in Japan…" (RSK 2011). That same day, the BMU delegated this task to the Reactor Safety Commission (RSK). They were tasked with determining whether German NPPs could withstand extreme events like those experienced in Japan, and whether the country's plants remained safe from a technical point-of-view with these potential hazards in mind. In other words, were Germany's plants robust enough to withstand a similar accident?

The RSK produced a 116-page report, released May 14, 2011, which addressed many of the technical concerns of the BMU. The RSK's report did not provide a technical reason or recommendation for keeping the eight nuclear power plants that had been shut down following the Fukushima accident offline (Lang and Lang 2011). The RSK had conducted a national assessment that "demonstrated [German NPPs had] a high

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Krümmel was the only reactor commissioned after 1980 to be included as part of these initial shutdowns. It had been connected to the grid on September 28, 1983 (IAEA 2017a).

resistance to stress" when considering three key risks highlighted by the Fukushima accident: "external hazards,[271] loss of power and coolant failure, [and] accident management measures," findings echoed by European stress tests undertaken in the months that followed (BMUB, 2016). The general finding was that, while there were some lingering issues regarding the robustness of German NPPs, "the problems that caused Fukushima to be a large accident, these problems or deficits did not exist in German nuclear power plants" (Waas pers. comm.; RSK 2011).[272]

In the aftermath of Fukushima accident, the German Government had assembled a parallel body to assess the ethical implications of the accident and what it meant for the future of the German energy supply mix. A 17-member Ethics Commission was established, headed by former CDU environment minister Klaus Töpfer.[273] The Commission was given a six-week mandate to provide recommendations to Chancellor Merkel on the future of Germany's energy supply mix and advise on the nuclear phase out.[274] Miranda Schreurs, a member of the Ethics Commission, noted that they were not tasked with an evaluation of "nuclear energy in a technical sense" in the same way the RSK was. Instead, it was meant to be a more holistic discussion on the ethical merits and challenges facing different energy systems: "We were looking at the [energy] systems

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[271] These include earthquakes, flooding, and extreme weather conditions.
[272] Schreurs (2012) points out that the RSK report did in fact highlight some deficiencies in German NPPs. She highlights the fact that the seven oldest plants were not designed to absorb a potential plane crash. Dr. Matthias Lang and Annette Lang (2011) note that the German plants could in fact withstand a small plane crash. While some of the newer NPPs could withstand a mid-size plane crash, none were designed to protect against a commercial sized aircraft (ibid.).
[273] He served in this role from 1987 to 1994 in the Kohl Government.
[274] The Commission included a range of experts from academia, industry, politicians, and religious leaders. For a full listing of the participants and their findings see: (Ethics Commission for a Safe Energy Supply 2011).

that have been around for the last decades, and even centuries when it comes to fossil fuels, and thinking about what needs to be done to change to a low carbon energy structure that is far safer than the one we believed we had now" (Schreurs pers. comm.).

They met from April 4 to May 28, 2011. While the RSK report found the nation's reactors to be operating safely, with proper contingencies in place in the event of an accident, the Ethics Commission came to a far different conclusion.[275] They argued that "the withdrawal from nuclear energy is necessary and is recommended to rule out future risks that arise from nuclear [power] in Germany" (Ethics Commission for a Safe Energy Supply 2011: 4). The Commission advocated for a societal effort to transition to a low carbon energy supply that phased out nuclear power within a decade, without jeopardizing the objectives of the 2010 *Energy Concept*.

In short, they argued that nuclear power posed too great a risk to society, and was ultimately not necessary to achieve the climate change objectives of the German Government. The report challenged the idea of technical risk, asserting that it was "not suitable for the assessment of nuclear energy", arguing that it "systematically leads to an unacceptable relativisation of risk" (Ethics Commission for a Safe Energy Supply 2011: 13). They reasoned that accidents like Fukushima highlighted the limitations of these

[275] Michael Sailer (pers. comm.), a member of the RSK, seemed to appreciate that there was a different form of risk being assessed by the Ethics Commission, when compared to the narrow technical focus of the RSK and was not surprised by the outcome. For his part, Ulrich Waas (pers. comm.) saw the outcome as technically and economically flawed. He had written to the members of the Ethics Commission to note his concerns, but was largely rebuffed, being told that it was not the role of the Ethics Commission to resolve the technical and economic challenges that might arise from a nuclear phase out (ibid). Given the decades-long nuclear debate, Waas understood why they felt the way they did but worried that they were not taking seriously the challenges associated with advocating for such a significant policy change; the transition to a low-carbon economy without nuclear power.

kinds of technical assessments and that it was "not ethically acceptable to dismiss as 'residual risk' those sequences of events and consequences of a disaster that lie outside of these (set) limits…" (ibid.). In the case of Japan, the plant's defenses were not built to withstand a tsunami of that height, or seismic activity of that magnitude, due to the low probability of such an extreme event, and yet "reality can disprove these assumptions" (Ethics Commission for a Safe Energy Supply 2011: 12). Given the alternatives available to Germany, the Commission recommended to Chancellor Merkel that it would not be ethical to continue to use nuclear power for electricity generation over the long term. The Ethics Commission called on Germany to make all efforts to phase out the technology within ten years, a timeline comparable to the one established by the Red-Green Coalition in 2002. They concluded that the eight reactors presently shut down should be permanently removed from service and that the remaining nine units should be shut down in order based on residual risk and grid requirements (Ethics Commission for a Safe Energy Supply 2011: 6).

The Merkel Government sided with the findings of the Ethics Commission. On June 6, 2011 the Federal Cabinet voted to rescind the extensions granted in December 2010, to make permanent the closure of the eight reactors that had been offline since March 15, and ordered Germany's nine remaining reactors to be shutdown between December 2015 and December 2022 (Hake et al. 2015; Kunz and Weight 2014). These policy changes were enacted formally through the thirteenth amendment to the AEA, passed by the *Bundestag* on June 17, 2011 and in the *Bundesrat* on July 8, 2011 (WNA

2017e).[276] This legislative change took place barely 6 months after the last amendment to the AEA which had granted lifetime extensions to Germany's nuclear fleet.

Spiegel's editorial staff likened Merkel's shift on nuclear policy to "the pope…suddenly advocating [for] the use of birth control bills" (*Spiegel Online* 2011). The CDU/CSU-FDP had for the better part of two decades differentiated themselves from the other parties (namely the SPDs and the Greens) using energy policy as a wedge issue. One stakeholder that I interviewed noted that this was "the last real topic in Germany that separated the CDU from the Greens" (Anonymous pers. comm.).[277] Others have criticized the move as nothing more than "an exercise in panic politics" (Mecklin 2012: 6). That being said, this abrupt shift in energy policy is not without precedent in German politics.

Earlier in this chapter we looked at how the SPD had shifted its stance on nuclear power during the 1980s following their electoral defeat. The SPD championed a massive nuclear expansion and the development of a 'plutonium economy' during the 1970s but following the 1982 election reversed their view on nuclear energy, rejected reprocessing and the development of fast reactors in favour of a gradual phase out plan. At the time, the SPD was trying to outmaneuver the Greens on the issue. In 2011, it was the CDU

[276] The amendment entered into force on August 6, 2011.

[277] This was one of the last roadblocks preventing the CDU and Greens from working together to form a Black-Green Coalition. Rüdig (2014) notes that the CDU and the Greens, have considered working together at the state and federal level in the past, however, they have yet to successfully negotiate the terms of a formal coalition. With the nuclear irritant removed it is likely we could see a Black-Green coalition in future elections, given the demise of the FDP at the federal level post-2013.

now seeking to stymie the popularity of the Greens.[278] The CDU was eliminating a key political wedge issue as they sought to rejoin the political mainstream on energy policy and pivot away from their past. The *2010 Energy Concept* was the first step in that political transformation, but the nuclear U-turn seemed to complete it. No major political party in Germany supported commercial nuclear power following the spring 2011 decision to reverse the licence extensions. Since then, a cross-party consensus has emerged that favours a German *Energiewende* without the use of nuclear power beyond 2022 (Hake et al. 2015).

This section made an effort to unpack how the political consensus regarding nuclear power developed in Germany at the federal level within the major parties while largely bracketing a discussion on civil society, and its role in this transformation. This next section returns to a discussion on nuclear waste. In the case of Germany, the unresolved question of how to handle its nuclear waste remained a central target for the anti-nuclear movement, and key to its political visibility as the issue of nuclear power began to wane during the 1990s.

Nuclear Waste and the Anti-Nuclear Movement

Gorleben, CASTOR Transports, and Reprocessing

While Germany tried to be proactive on the issue of nuclear waste, efforts to get a DGR built have proven largely ineffective. As noted earlier, the Gorleben site has been actively opposed since it was first identified by the Government of Lower Saxony in the

[278] Given the German coalition style of government, it is more accurate to say that the CDU/CSU-FDP were seeking to prevent the SPD-Greens from returning to Government both at the federal and state level.

1970s.[279] This, however, did not deter industry and federal officials from pursuing it as a site for a national DGR.

From 1979 to 1983 federal investigations confirmed the suitability of the site for a high-level waste (HLW) facility. From 1984 to 1986 above-ground interim facilities were installed on-site and early underground exploration was conducted (Hocke Kallenbach-Herbert 2015). The Kohl Government actively excluded critical voices from the licensing process during this period in an effort to avoid any further delays, however, this proved to be an ineffective political tactic. From 1986 to 1998 progress on a permanent HLW geological repository largely stalled (Hocke and Renn 2009).

Exploration had been stalled by protests and legal actions which led to a series of court injunctions halting work on-site. During this period, waste continued to be shipped to Gorleben's interim waste facilities, but only limited exploration was undertaken to advance the geological repository. Germany's preference for centralized interim storage meant that German operators did not invest in large on-site storage facilities as is the industry norm in countries like the US and Canada. This made it necessary to make regular shipments of spent fuel to Gorleben and Ahaus. Protests and legal injunctions further complicated transport of waste to and from Gorleben, including for the purposes of exporting spent fuel to the UK and France. While the legal requirement for

[279] Gorleben is not the country's only site for nuclear waste management, but it has been the most controversial. Other facilities include Ahaus (a central interim storage facility for high and intermediate level waste), Morselben (a former Eastern European facility which operated from 1981-1998 for low and intermediate level waste), Asse Salt Mine (another closed facility that operated from 1967-1978, used to house low level waste), and a planned facility at the Konrad mine (for low and intermediate level waste) (WNA 2017e; BfS n.d.). There is also an interim facility near Lubmin used to house all forms of waste produced at the former East German NPPs.

reprocessing spent fuel had been abandoned in 1994, it was still industry practice to export spent fuel for reprocessing to La Hague in France and Sellarfied in the UK. In total, there were 166 casks shipped abroad for reprocessing from 1979 to 2005 (WNA 2017e). There was another 206 tonnes of waste reprocessed domestically from 1971 to 1991 (ibid).

By the 1990s there were no new reactors being built, fast reactors had been cancelled, and the idea of domestic reprocessing had been abandoned. CASTOR transports (shipments of spent fuel) were the last highly visible way of protesting what remained of Germany's fledgling nuclear industry, and served as an opportunity for disrupting their day-to-day operations. 'CASTOR' refers to the model of dry cask used to transport spent nuclear fuel.[280] Alexander Glaser (2012) asserts that the anti-nuclear movement was able to transform the otherwise mundane industrial practice of fuel shipments into a national media spectacle. These shipments became a focal point for nuclear protests, leading to demonstrations ranging in size from 4000 up to 10 000 people between April 1995 and March 1997. They created national media events that required thousands of police to protect the shipments and maintain the peace.

At the time, Greenpeace advocated stopping waste shipments as an alternative means of effectively getting German NPPs to shut down given their limited on-site storage capabilities (Rüdig 2000). These protests were raising the costs associated with shipments of spent fuel for reprocessing and making it challenging to continue to operate German NPPs that had excess spent fuel on-site (Mez and Piening 2006). This issue became more pronounced when CASTOR shipments were halted following a May 1998

[280] CASTOR is an acronym for 'cask for storage and transport of radioactive material.'

incident which raised safety concerns over the industry practice.[281] This left German NPPs in a precarious place, with their waste management system in disarray.

The Green Party had as part of their electoral platform long called for an end to the reprocessing of spent fuel abroad and CASTOR fuel shipments. They had also publicly called on industry to abandon Gorleben as a site for Germany's HLW repository (Rüdig 2000). CASTOR shipments became a bargaining chip in the negotiations for a nuclear phase-out following the 1998 elections.

The nuclear consensus established in June 2000 succeeded in establishing an end to reprocessing and set in motion plans for a nuclear phase out, but the question of Gorleben and CASTOR shipments had proven difficult to settle. CASTOR shipments were allowed to resume in exchange for the nuclear operators agreeing to build interim on-site facilities for waste. This would serve to limit the need for future shipments to Gorleben and Ahaus. By contrast, the permanent HLW repository could not be abandoned or replaced so easily.

German nuclear operators had invested over €1.5 billion into the proposed HLW repository at Gorleben and were reluctant to abandon it as a site. The federal government proposed a compromise and opted to postpone a decision on the future of the site by

[281] Media reports had suggested the shipment did not meet the stringent safety requirements mandated by the licence for the shipment of spent fuel (Rüdig 2000). Shipments were "voluntarily" halted by the operators at the behest of the BMU, leading to a lengthy internal review of the process (Sigmund and Kölpin 2004). Investigations later revealed that "a 'significant number' of spent fuel shipments to the COGÉMA plant…[were in] non-compliance with the established contamination limits"(ibid). Sigmund and Kölpin (2004) suggest that this was a case of the BMU being over-zealous, noting that similar technical breaches did not stop fuel shipments to the UK and France from Switzerland, the Netherlands, or Japan. The incident ultimately led to new stricter criteria for CASTOR shipments being introduced by the BMU in 1999 before shipments could resume.

imposing a ten-year moratorium on the study of Gorleben. The consensus document noted that the industry was not relinquishing the site, but that they had agreed to halt investigations for the duration of the moratorium (Agreement Between the Federal Government and Utility Companies 2000).[282] Exploration of the Gorleben site was halted from October 1, 2000 through to September 30, 2010 (BfS 2016).

Rebooting the Process?

Following the moratorium, a new site selection process was initiated to try to reboot the long-stalled process. In July 2013, the *Repository Site Selection Act* (StandAG) was passed calling for a new site selection process, with an ambitious timeline for siting and building a national DGR in Germany designed to handle HLW. StandAG's timeline called for a siting process to be drafted by 2016, with potential sites identified by 2023, a final site selected by 2031, and a facility operating by 2050 (K. Loew pers. comm.; Hocke and Kallenbach-Herbert 2015). The Federal Office for Radiation Protection (BfS), the federal agency responsible for handling waste disposal, acknowledged that the timeline was ambitious but had confidence that the timeline was still achievable (Loew pers. comm.).[283] StandAG also called for the formation of a commission to set out the key criteria for how the siting process would proceed.

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[282] The agreement also committed the Government to licensing Konrad, an old iron ore mine to be used as a permanent repository for low and intermediate level waste. The construction licence was not granted until 2008, following a series of court challenges. It is not expected to be operational until 2022 at the earliest (WNA 2017e). Like Gorleben, Konrad has been under review since the mid-1970s.

[283] Klaus Loew (pers. comm.) of the BfS conceded that there will be challenges but that it remains their aim to uphold the provisions of the StandAG: "Based on its experiences gained in the 25 years since it was founded, the BfS is are aware that there may be delays due to the very complex issues to be solved over such a long period of time. In that respect, the legally prescribed schedule is ambitious. Irrespective of this, it is the BfS' aim to achieve compliance with the legal provisions."

The Commission on the Storage of High-Level Radioactive Waste (HLWC) was established in May 2014. It brought together a cross-section of experts and representatives from society, including academics, parliamentarians, environmentalists and delegates from trade unions, and others (WNA 2017e).[284] From the outset, the HLWC was tasked with treating Germany as a "blank map" to find the most geologically appropriate site for a DGR using a process that would be socially acceptable to the German people (Appunn 2017). In practice, this meant keeping Gorleben open as a potential site for the German DGR. Michael Sailer (pers. comm.), a member of this expert commission, asserts that keeping all options on the table was a challenging but important political compromise necessary for moving the process forward. As part of the deal that had ensured the passage of the StandAG, work at Gorleben had been put on hold while the Commission revisited the siting process.[285]

After a lengthy two-year process, the HLWC's final report was released on July 4, 2016.[286] The HLWC's report drew on lessons learned from the German experience. It noted that the process cannot be narrowly defined as a technical task divorced from the political, underscoring the idea that "politics will always play an important role in the new procedure" (HLWC 2016: 4). To that effect, at each phase of the site selection process, they established a requirement for the decision to be approved by the *Bundestag* and *Bundesrat*. They considered existing critiques of Gorleben, namely that it had been selected for principally political reasons, and sought to refute this. It is not an either/or

[284] The commission's name in German is the: *Kommission Lagerung hoch radioaktiver Abfälle*.
[285] Exploratory work was stopped in November 2012, and then formally halted on July 27, 2013 when the StandAG came into force.
[286] For an English translation of the summary report see: (HLWC 2016).

approach, but rather a one that must embrace the complexity of such a long-term and difficult societal decision. They insisted that political, social, and technical criteria would continue to inform the process moving forward.

The HLWC's work is laudable on many fronts. It sought to produce a siting framework that would lead to a socially acceptable and technically safe means for storing HLW for up to a million years. The HLWC's work was as transparent as possible with its deliberations broadcast on television and available online. Citizen dialogues allowed for interested members of the public to engage with the HLWC as well as comment on earlier drafts of their work.

Of particular interest is the Commission's recommendations regarding the need for legislative reform. The HLWC recommended key changes to the *2013* StandAG that included restructuring key government and private sector agencies tasked with waste disposal (interim and final storage), spent fuel shipments, and the site selection process for the HLW DGR. This shifts the responsibility for long-term waste management from industry-owned organizations and existing state and federal authorities and places it under the purview of one central agency, the BGE.[287] This recommendation was adopted in the *2016 Act on the Organisational Restructuring in the Field of Nuclear Waste Management*.[288] In short, the BGE will be a federally-owned state corporation that sites,

[287] BGE is the acronym for the German spelling of the organization: *Bundesgesellschaft für Endlagerung.* The BGE will combine the responsibilities of the BfS, the industry-owned *Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH* (DBE), and the Asse GmbH.
[288] In German, this is referred to as the: *Gesetz zur Neuordnung der Organisationsstruktur im Bereich der Endlagerung.*

builds, and operates Germany's nuclear waste facilities under the supervision of the BMUB.[289]

The HLWC has also recognized the importance of building public trust in the process as a prerequisite to getting acceptance for the siting, construction, and operation of a DGR. Central to this objective will be incorporating public participation early in the process through citizen dialogues, and regional conferences, with transparency and fairness built into the process. There was a recognition that this project will require "offers of participation that go beyond the standards seen in infrastructure projects so far" (HLWC 2016: 14). They, however, did not want to suggest that this would amount to a veto that could block the project. Instead, they will be able to shape the process alongside the BGE, with the ability to have critical input that can "improve upon the process…but [does] not entail the risk of endangering the whole process through blockades" (ibid.). The Commission envisions the community being involved at each step of the process, but leaves the final approval with the *Bundestag* and *Bundesrat*. This is intended to avoid the errors of the past that caused the process to stall time and time again. This new approach appears to be a marked improvement over past efforts to site a DGR in Germany.

It remains to be seen whether the criteria laid out in their report will help Germany achieve its goal of selecting a site by 2031 as mandated by the legislation, and have a facility operating by 2050. A leading member of the expert commission on waste, Michael Müller, has suggested that the mandated schedule is "logistically impossible",

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[289] The legislation also made changes to who will operate the interim waste facilities at Gorleben and Ahaus. On August 1, 2017, responsibility will be transferred from the industry-owned consortium, the GNS (*Gesellschaft für Nuklear-Service mbH*) to the newly formed, state-owned BWZ (*Bundes Gesellschaft für Zwischenlagern*) (WNN 2017b).

with a repository not likely to be ready anywhere near the 2050 deadline set out in the 2013 legislation (quoted in DW 2016a). The final report from the HLWC concedes that a DGR might not be operational till after 2100.

It appears as though the political paralysis of the last 40 years surrounding the future of Germany's nuclear waste is unlikely to be resolved in the near term, no matter how many times the decision-making process is rebooted. Critics of the HLWC have suggested that they have simply "delayed" a decision rather than provided a workable framework to adequately address this longstanding impasse (DW 2016a). Decision-making surrounding nuclear waste management in Germany has until now resisted a trend towards deliberative democracy. Rather than integrate affected communities into the process, they continue to be largely excluded through a process driven by federal legislators, expert commissions, and German bureaucrats. While the process proposed by the HLWC aims to correct some of these historical shortcomings, it is too soon to assess how effective they will be. The substantial investment nuclear operators have made in the Gorleben site has made it difficult to abandon the site and move on.[290] For its part, the HLWC recommended exploration at Gorleben remain on hold through to March 2017. Müller notes that the geological requirements for a site will eventually force Gorleben out of the running. He asserts that he was in favour of removing Gorleben from the outset of the report, but that "it will soon be out of the running anyhow, as the salt dome is not geologically suitable as a site" (DW 2016b). Until it is formally ruled out as a site, the

[290] This is not unique to the German case. A similar on-and-off again battle has been played out over Yucca Mountain in the United States. For a colourful account of the most recent effort to revisit the use of Yucca Mountain as a site for American HLW see: (Zhang 2017).

mines at Gorleben will be maintained as part of a deal brokered with the state of Lower Saxony (BfS 2016).

Post-Phase Out: Lingering Legal Issues and the not-so simple matter of Who Pays?

As noted above, within days of the Fukushima accident in Japan, the German Government acted swiftly to shut down seven reactors built before 1980, in addition to Krümmel which had been offline at the time. Initially part of a 3-month moratorium, the closures became permanent in June 2011. Perhaps not surprisingly, the nuclear operators initiated a series of legal challenges to recuperate losses from the unexpected forced closure of their NPPs. There were also a separate series of court challenges related to the legality of the nuclear fuel tax imposed in 2010 as part of the deal to extend the operating licences of Germany's NPPs. The tax remained in place, even after the extended licences had been rescinded in 2011.[291]

The German utilities (E.ON, RWE, and Vattenfall) ultimately took their challenge to the Federal Constitutional Court (*Bundesverfassungsgericht)*, Germany's supreme court. The utilities challenged the legality of the 2011 shutdown of eight reactors, and the 13th Amendment to the AEA that formally rescinded the life extensions granted in 2010. They argued that it was tantamount to expropriation and that this entitled them to compensation from the federal government (Chazan 2016a). "The court dismissed the Energy Companies' expropriation claim, but held that Germany had violated their legitimate expectations" (Zielinski 2017). The court ruled that the 11th Amendment to the

[291] Broadly speaking, there are four issues being raised by the industry in their legal cases against the federal government. They are challenging the legality of the 13th Amendment to the AEA, the fuel tax, the law that currently bars the shipment of reprocessed fuel to Gorleben, and are seeking compensation for the costs associated with the 3-month moratorium in 2011. For a brief overview see: (Reuters 2016b).

AEA passed on December 8, 2010 (which had granted extended operating licences to Germany's nuclear fleet) gave the utilities the legitimate expectation that they would be able to operate their reactors for more time leading them to make investments in line with those expectations. The court ruled that reversing this position on March 16, 2011 without a transition period or proper compensation was a violation of their constitutional rights (Zielinski 2017; *BVerfG* 2016a). While the 13th Amendment to the AEA was found to be constitutional, the utilities were nevertheless entitled to "adequate compensation" arising from the reasonable expectation that their investments in their reactors would be protected for the duration of the life extension (ibid.). "Investments seemed to have been encouraged and it had not been foreseeable that the government would change its position again within the same legislative period" (Zielinski 2017). The court has given the federal government until June 2018 to make arrangements with the affected utilities (Chazan 2016a). Media reports have suggested that compensation claims for E.ON, RWE, and Vattenfall together total €19 billion (Eddy 2016).[292] The federal government for their part has made clear that they do not expect there to be any major payouts to the nuclear industry as a result of this ruling (Chazan 2016a). Part of the reason for this is because the government had been in ongoing negotiations with industry seeking to conclude a financial settlement that includes waste and decommissioning costs resulting from the nuclear phase out.

[292] EnBW opted not to participate in this lawsuit given its status as a state-owned utility. They have unsuccessfully sought compensation related to the 3-month moratorium but are in the process of appealing (Reuters 2016b). E.ON and RWE have also lost legal cases specifically related to the 3-month moratorium, but are in the process of appealing those decisions as well.

In the months leading up to the constitutional court's ruling, there had been two expert commissions studying the matter on behalf of the German Government. In addition to the aforementioned HLWC exploring the question of siting a DGR, there was another expert commission determining how costs might be divided between the major utilities to pay for it, in addition to other costs associated with the phase out including the decommissioning and dismantling of their reactors. Until recently, the nuclear industry had been responsible for costs associated with waste and decommissioning, amounting to approximately €45 billion (Bayar 2016). At issue for the commission was the widespread concern over whether the utilities would be financially capable of fulfilling these obligations long-term.[293] To date, Germany's nuclear operators have allocated approximately €38 billion for this purpose (Chazan 2016c).

In April 2016, the Commission on the Review of Funding for the Phase-Out of Nuclear Energy (KFK)[294] released its findings. They provided a key recommendation that proposed effectively transferring responsibility for waste management from industry to the federal government. Industry would still maintain responsibility for the decommissioning of their reactors. This proposal required nuclear operators to pay €17.4 billion into a government-managed fund to cover the costs associated with the intermediate and long-term management of their nuclear waste, leaving the utilities with approximately €20 billion to pay for decommissioning costs (Flauger and Stratmann

[293] German utilities, in particular RWE and E.ON, have been suffering historic losses since 2011 that are putting their financial future into doubt post-phase out (Chazan 2016b). RWE posted losses of €5.7 billion for 2016 while E.ON reported losses of €16 billion (Chazan 2017b). For a good discussion of the challenges facing the industry see: (Kreijger et al. 2016).

[294] KFK is the acronym for the German spelling: *Kommission zur Überprüfung der Finanzierung des Kernenergieausstiegs*.

2017; Chazan 2016c). The KFK also called for operators to pay a "risk premium" to cover any potential cost overruns associated with the long-term management of Germany's waste. They suggested 35 percent (or ~€6 billion) be added to the expected total cost to ensure that future generations would not be left to pay for Germany's nuclear waste legacy (ibid).[295] Effectively this meant that utilities would have to pay a total of €23.4 billion for nuclear waste management.

While initially the utilities had been reticent to consider such an arrangement, in light of the costly risk premium attached to it, they have since changed their tune. On October 19, 2016, it was announced that all four nuclear operators had accepted the terms following negotiations with the federal cabinet. While costly in the short-term, the deal will place a cap on nuclear operators' liabilities associated with intermediate and long term waste management and transfer that risk onto the federal government. Legislation formalizing this deal was enacted in December 2016. Given the unresolved matter of the legal challenges the German Government still faces, the terms of the phase out are far from being finalized.

The Merkel Government continues to work with the big four utilities to get them to drop their legal claims related to the phase out and the fuel tax as part of their discussions over how the waste fund will be paid for. As part of a *quid pro quo* it is expected that terms can be reached whereby the German Government assumes a greater

[295] Only a month earlier there had been suggestions that a 100 percent risk premium might be used bringing that total up to €36 billion (Chazan 2016b). The members of the KFK needed to balance the interests of the German people with the interests of the utilities, taking into consideration their ability to pay for this proposal (ibid.). The KFK's final report was clearly a compromise that had emerged in order to try to secure buy-in from all parties involved and advance a workable solution.

share of the costs associated with the waste fund in return for litigation being dropped. These negotiations have long held the promise of helping to resolve lingering legal claims against the government related to the phase out, and led some to argue that the court cases were merely being used as leverage to limit the industry's liabilities associated with waste and decommissioning (Chazan 2016b).

Litigation over the fuel tax remains a key sticking point in these negotiations according to media reports (Flauger and Stratmann 2017). While nuclear operators have demonstrated a willingness to drop legal claims associated with the phase out, the fuel tax remains off the table. To date, these taxes amount to roughly €6 billion (ibid.). The Federal Constitutional Court is expected to rule on the legality of this tax later this year (Reuters 2016a). The favourable decision rendered in late 2016 in conjunction with a potential victory on the fuel tax is likely to only further the industry's claim that the federal government should pay a greater share of the costs associated with the phase out. This may help to explain the nuclear operators' optimism for 2017 and beyond. E.ON has suggested that 2016 "would be the 'last to reflect the burdens of the past,'" while RWE is expected to return to profitability in 2017 after having agreed to write down the costs associated with its share of the waste fund in 2016 (Chazan 2017a; Chazan 2017b). While negotiations are far from over, it does appear that a deal is likely to be reached in the near term that will bring an end to this contentious chapter in German energy politics.

Energiewende without Nuclear

In the background to the protracted nuclear debate, the German transition to a low carbon economy continues. With plans for the last reactor to be shut down in late 2022, the push has been towards renewables, largely as outlined in the *2010 Energy Concept*

with financial incentives being provided by the *2000 Renewable Energy Sources Act* (REA) through a feed-in-tariff (FIT or EEG). By and large, the German *Energiewende* has surpassed expectations in terms of promoting the growth of solar, wind and biogas, but has been far less successful in reducing emissions and reducing the cost of electricity for consumers.

In 2000, renewables accounted for only 6.3 percent of Germany's electricity generation. Today, they account for approximately 29.5 percent of the electricity generated in Germany (Morris 2017).[296] Germany first introduced a feed-in-tariff in 1991.[297] The *Erneuerbare-Energien-Gesetz* (EEG) refers to the amended version of the German FIT introduced by the REA in 2000. The 2000 REA increased the value of the FIT, providing fixed prices that served to further incentivize the development and deployment of renewable technology in Germany, while also prioritizing their access to the grid (Hake et al. 2015). By December 31, 2022, when the last nuclear reactor is scheduled to go offline, German renewables are expected to make up to 40 percent of the supply mix (Bruninx et al. 2013).

Early indications suggest that the negative effects of the nuclear phase out through to 2022 will be relatively minor, particularly in terms of security of supply (Kunz and Weight 2014). Challenges that remain include issues related to grid congestion, increases to emissions in the short and medium term, a continued reliance on fossil fuels (namely

[296] This figure comes from AEGB group, and refers to Germany's "gross power generation from 2016 including exports" (Morris 2017). Other reports put the renewables figure at 33 percent (Buchsbaum 2016). This is comparable to where nuclear was at in the year 2000. By contrast, today nuclear only accounts for 13.1 percent of Germany's gross power generation.

[297] The predecessor to the EEG was the *Stromeinspeisungsgesetz* (StrEG).

coal and lignite), and difficulty securing investment for maintaining conventional generating capacity still needed for grid stability (ibid.).

Bruninx et al. (2013) highlight how the rapid shift to RES is exacerbating the limitations of the German grid. The congestion on the transmission lines is not as a result of the nuclear phase-out *per se*; it has more to do with where new RES capacity is located on the grid. The tremendous growth in RES, in conjunction with the closure of nine nuclear reactors, has shifted much of Germany's generating capacity to areas with limited transmission capacity. In other words, wind farms and solar panels are being put up in regions that lack the infrastructure necessary to send the electricity to where it is needed. This is causing certain parts of the grid to become unstable. "In particular, congestion in the northern part of Germany, the connection North-South and the northern interconnectors limits the consumption of available power from RES" (Bruninx et al. 2013: 260). Spikes in RES supply are difficult to control for and can cause a grid to overload. German RES capacity has had to be curtailed and/or redispatched to avoid overloads in particularly problematic areas of the German grid.[298] Germany desperately needs to upgrade existing grid infrastructure to address these transmission problems.

The German Government has tinkered with the *Energiewende* since 2010 by modifying the FIT, and using legislation to identify and expedite urgent transmission and grid upgrades needed to resolve these early technical challenges. In 2013, there were 36 high priority transmission projects, worth approximately €10 billion, that the German government identified as requiring immediate attention in order to increase the use of

[298] In particular, Bruninx et al. (2013) note that in 2012 RES was limited in Berlin and Hamburg, but there are a number of other areas on the grid that are being destabilized by high contributions from RES.

RES (WNA 2017e). These projects included the construction of over 4000 km of new transmission lines by 2022, an ambitious target for a project that was already well behind schedule (The Economist 2013). In 2016, the *Bundesnetzagentur* (BNetzA), Germany's federal agency charged with regulating its electricity grid, suggested that Germany in fact "required 7000 km of new transmission lines at €35 billion, with priority given to the three north-south links by 2022 when the last nuclear plant is due to close" (WNA 2017e). The Merkel Government responded in the summer of 2016 with a series of new pieces of legislation designed to curtail the growth of RES, improve grid congestion issues, and reduce electricity costs for the consumer (Buchsbaum 2016). Notably, the new legislation will limit how many new renewable projects get approved for the FIT and where they can be built. "The new capacity limits are aimed at slowing the tide of renewable energy flooding the market, giving the expansion of grid infrastructure time to catch up" (Houston-Waesch and Grimm 2016).

In the meantime, Germany is expected to continue to rely heavily on coal and lignite to meet its electricity needs. At present, roughly 40 percent of its electricity supply comes from coal and lignite, doing little to help Germany reach its target of a 40 percent emissions reduction by 2020 based on a 1990 baseline (Zha et al. 2017; Appunn 2017). To date, the Merkel Government has resisted calls for a coal phase out, suggesting market pressures will lead to a phase out ahead of 2050 (Reuters 2016c). The strength of the German coal industry in conjunction with the need for grid stability has made a coal phase out exceedingly unlikely in the near term.[299]

[299] While environmental groups in Germany are opposed to the continued use of coal and the subsidization of coal mining, the nuclear phase out was always seen as a priority (Hatch 1995). This struck me as somewhat perplexing giving how emissions-intensive

The *Energiewende* as an alternative approach to achieving the low carbon economy has transformed how Germany generates electricity,[300] but in the short term has done little to get the country off fossil fuels or to reduce its emissions; meanwhile, its consumer electricity rates have soared. Germany presently has the distinction of having some of the highest electricity rates in Europe, second only to Denmark (Houston-Waesch and Grimm 2016). BNetzA is warning consumers to expect even higher electricity prices post-2022 when the last reactor comes offline (Parkin 2017). The costs associated with grid expansion, the maintenance of grid stability, and the FIT along with the costs associated with the phase out have all played a role in driving up electricity prices in Germany. While the German *Energiewende* has avoided serious and acute challenges, namely blackouts, other negative externalities seem unavoidable at this point both for the short and medium term.

Conclusion

This chapter sought to explore how the political consensus amongst the federal political parties shifted from one that saw nuclear power as integral to Germany's energy security and economic success, to a technology best abandoned as the country transitioned to a low carbon economy. Germany's decision to abandon nuclear power

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coal is in comparison to nuclear. One consultant noted that it had more to do with questions of safety as opposed to emissions (C. Wörlen pers. comm.). Germany's long history with coal and the policies that served to shape public attitudes towards the fuel remain beyond the scope of this dissertation. For an interesting discussion of the future of coal and the *Energiewende* see: (Renn and Marshall 2016).

[300] It is also worth noting that the *Energiewende* has dramatically shifted who is responsible for generating electricity in Germany. The massive renewables expansion has been taken on by over 800 smaller utilities, energy cooperatives, and private citizens. They make up roughly 95 percent of the total installed capacity of RES, versus a mere 5 percent by the big four (Buchsbaum 2016; Buchan 2012).

was not developed as an abrupt response to a nuclear accident in Japan or series of accidents abroad. Instead it was an issue that had been hotly contested for decades in Germany. This chapter provided an overview of the political context in which this policy was developed and gradually enacted over time.

It discussed how Germany's ambitious nuclear policies from the early 1970s enjoyed support from all major parties in the *Bundestag* and at that time were advanced with little debate or scrutiny. During the 1970s, the federal government was focused on economic growth at all costs, and saw nuclear power as a tool to achieve this objective in the post-war period as part of its so-called *Modell Deutschland*.

Early signs of political unrest were visible but lacked a voice in government. Instead, they took shape outside of government in the form of citizen initiatives, organized demonstrations, legal challenges in the administrative courts, and violent clashes at proposed nuclear sites. Federal political parties acknowledged this discontent at their party conferences, but did not alter their policies towards nuclear power in any substantive way. The nuclear issue was debated internally but early efforts to support a nuclear moratorium proved unsuccessful in Germany.

As the nuclear industry's growth began to stall in the late 1970s, they began to focus their attention on lobbying the federal government rather than engaging with the public in the national debate over nuclear power's place in the supply mix. The political climate surrounding nuclear power was changing in Germany, but the industry and the federal government were slow to recognize this change. It is important to remember that while demonstrations and protests were large in number, federal political parties maintained a strong consensus regarding the national energy policy and the nuclear issue

through to the early 1980s. Those interviewed for this chapter from industry acknowledged that while there were some organized efforts to engage the public at this critical juncture, they were not particularly effective in swaying public opinion.

The politics surrounding nuclear power began to change with the 1983 federal election and the emergence of the Green Party on the national stage. When the 1986 Chernobyl accident took place, it was the CDU-led Kohl Government on the defensive, as the SPD, in conjunction with the Greens, called for Germany to transition away from its reliance on nuclear power. In just one election cycle, nuclear power had gone from a non-issue among the major political parties to a key wedge issue. When the Red-Green Coalition came to power in 1998, it had ceased to become a question of if but when Germany would seek to phase out nuclear power.

By the time the Merkel Government was in a serious position to revisit the nuclear phase out, following the 2009 election, the political climate was such that they were only able to delay rather than reverse the phase out. The political cost of a full-throated endorsement of nuclear power was simply too high. Instead, it was presented as a bridge technology, as part of a broader transition towards a low carbon economy. Nuclear power had been effectively transformed from an essential tool needed to help modernize and rehabilitate the German economy, into a necessary evil only to be tolerated as a bridge technology until renewables were mature enough to replace it. The German public was reticent to accept this political justification for extending nuclear licences prior to the Fukushima accident and outright hostile to it afterwards. Nuclear power had become for all intents and purposes politically taboo for Germany, one neither the industry nor a political party could revise or revisit.

Some of the hallmarks of the German case include: the effective mobilization of the anti-nuclear movement, the growth of a successful Green Party (at the state and federal level), and the inclusion of institutionalized counter-expertise within the regulatory process. These features are not necessarily unique to Germany,[301] but taken together, they built the momentum necessary to fundamentally alter the perception of nuclear power. The high political visibility these groups gave to the nuclear issue in conjunction with their ability to keep it relevant for such a sustained period of time helped to facilitate this gradual political transformation.

Environmental think tanks' ability to establish themselves as a credible source of counter-expertise on nuclear power proved critical. More to the point, the access they (and other elements of the anti-nuclear movement) had to government officials and to the regulatory process is what sets the German case apart from the others. This is evidenced by their inclusion in expert commissions like the Gorleben International Review, the 2011 Ethics Commission, the HLWC, and many others discussed throughout this chapter. The German Government has been lauded in the past for providing greater access to environmental groups and for the influence they have traditionally enjoyed in the country's decision-making process (Nelkin and Pollak 1982; Joppke 1993; Schreurs 2002; Vasi 2011). The German framework provides greater opportunities for these diverse opinions to be heard in public policy debates. This access extends well beyond an environmental assessment process as we have seen in Canada and Finland. This framework has allowed for a more holistic approach to safety and risk and served to

[301] For example, the Green Party has been part of governing coalitions in Finland, as discussed in an earlier chapter.

better reflect the non-technical concerns of the public as it related to nuclear power in Germany. This approach is far more responsive to the public than any other model explored in this dissertation.

While elements of the *Energiewende* appear to be sub-optimal, it is a project that continues to enjoy the support of the vast majority of the German public (Keating 2016).[302] While the protracted policy debate over nuclear power has ultimately led to its untimely demise, it is worth noting that it has done so with strong public support. The German case provides us with an alternative model for decision-making that broadens our understanding of expertise and highlights the role traditional outsiders can play in successful policy development. Elements of the German approach might prove effective for other countries as they seek to increase public participation in their decision-making process around energy policy.

[302] Keating (2016) notes that upwards of 90 percent of Germans continue to support the Energiewende.

Chapter 7: Conclusion

In the preceding chapters, this dissertation sought to unpack some of the factors that have led some democratic states with existing commercial nuclear power programs to continue to endorse the technology as part of their supply mix, while others chose to shutter their plants and pursue alternative energy paths. Even when states endorsed nuclear power as a viable and necessary component of their electricity generation portfolio, in some cases they still encountered roadblocks that prevented the successful completion of new reactors. This dissertation created a typology with three principle energy trajectories for states with existing commercial nuclear power programs as an analytical tool for helping to isolate and identify some of the key the factors that serve to shape the decision to expand, maintain, or phase out the use of the technology. Using Finland, Canada, and Germany, this project explored most similar cases with differing outcomes. They represent three northern democratic states that are experienced nuclear operators that ultimately adopt very different policies towards nuclear power during the nuclear renaissance. This study sought to better understand the factors that that led to such divergent outcomes.

Exploring Three Divergent Energy Trajectories: Not Exactly as Planned

Using many of the factors flagged in the literature review, a series of hypotheses were developed for each of the nuclear trajectories. They were thought to, at least in part, inform some of the factors that shape a country's nuclear trajectory. While far from conclusive, they were meant to provide a starting place to begin to discern what variables were significant in determining a country's policy towards commercial nuclear power. What I found was that while some factors were present in the cases explored in this

dissertation, they were not necessarily as influential as initially thought. It is also important to concede that there were unanticipated factors that came out of my study that were not included in the original research design.

In chapter 3 it was acknowledged that not all of these variables would be necessary or sufficient to explain why a state opts to expand, maintain, or phase out nuclear power. Instead they should be viewed as partial explanations that help to clarify why some countries are able to continue to build and operate nuclear reactors, while others interested in doing so fail to achieve the same results. I will begin by reviewing the overall findings from each case study and compare them to the hypotheses laid out in chapter 3. I will then undertake cross-case analysis meant to the highlight the windows of opportunity for expansion along with the points of vulnerability and veto found within the drawn-out decision-making process. I will conclude with an assessment of this dissertation's contribution to the literature and a brief discussion of the lessons learned from this study and potential areas for future study.

A State Opting to Expand: Finland

Finland is a country with over 30-years of experience operating four commercial reactors at two sites: Loviisa and Olkiluoto. During the period of study, the Finnish Government approved four major nuclear projects. They included: the construction of a DGR for HLW, two new reactors at the Olkiluoto site, and a new plant at Pyhäjoki. Today, only three of those projects are being advanced by their proponents: the Posiva DGR, OL3, and the NPP at Pyhäjoki.

Eight factors thought to be relevant to the decision-making process (based on the literature review conducted in chapter 2) were advanced by this thesis. It was expected

that in a case of nuclear expansion: (1) the Finnish Government would be supportive of both the nuclear industry as well as nuclear R&D; (2) STUK, the regulator, would work cooperatively with industry to help deliver projects in a timely manner; (3) effective communication from industry and/or government officials would be used to connect with the public and policymakers to convince them of the benefits of the technology (i.e. as a cost-effective source of low emissions electricity); (4) opposition groups would have limited access to policymakers or be ineffective in their messaging; (5) the public would be supportive of nuclear power, disengaged from energy policymaking, or not included in the process in a substantive fashion; (6) economics, financing, and technical barriers would be accounted for and well-managed; (7) a waste management plan would be in place and positively correlated with nuclear expansion; and (8) the supplier of the NPP(s) and related-financing plans would acceptable to the public and policymakers (see Table 7 for an overview of the results).

In the case of Finland, many of these factors were present, however, they did not necessarily have the effect(s) the researcher had anticipated. For example, strong government support for nuclear power did not guarantee a DiP would be granted for all applications, nor could it ensure that a project would be advanced successfully thereafter. Additionally, technical barriers, cost overruns, and challenges with the regulator as experienced by Areva at OL3 would have been thought to dampen interest in more capacity, however the three DiP applications submitted to the Government in 2010 seem to run counter to this logic. That being said, other variables like the role of waste management in Finland and the limited effectiveness of environmental groups in the decision-making process, seemed to be positively correlated with the decision to expand

nuclear capacity (as expected). So, what does this really tell us about the factors that shape a country's decision to expand their nuclear capacity in the twenty-first century?

First, context is important, and some elements will remain idiosyncratic to Finland. It was one of the first countries to test the waters of the so-called nuclear renaissance. This era of nuclear expansion had held the promise of increased performance and profitability for the next generation of reactors. It was expected that new manufacturing techniques, in conjunction with improved designs and project management, would lead to better results for new builds right out of the gate. Instead, the Finnish experience has consistently demonstrated that forecasted costs and construction timelines for nuclear projects are nowhere near industry expectations, with limited signs of improvement. However, Finnish utilities and the industries that support them (through the Mankala Principle) have shown remarkable resilience and persistence. This is evidenced by the fact that the two reactors currently planned or under construction are being advanced by Mankala companies.

Finnish forestry and heavy industries' ownership of nuclear power plants plays a central role in explaining the expansion of nuclear capacity in Finland. They have used the ownership of power plants as a means of protecting their competitive advantage in their respective industries, while also using it to secure political support for their expansionist ambitions. They believe that large-scale NPPs will insulate them from price fluctuations in the Nord Pool Market, and potentially costly imports of natural gas and/or electricity from Russia.

Finnish utilities have demonstrated that under the right conditions it is still possible to secure the necessary political, economic, and social support needed to build a

reactor in a Western-democratic state. But, it is important to note that well-heeled consortia capable of enduring these lengthy delays may in fact be outliers in increasingly competitive electricity markets where alternatives can be built with fewer political obstacles, on faster timetables, and at a fraction of the cost.

This dissertation's emphasis on the DiP process and the national political debate surrounding nuclear power, with hindsight, fails to capture all the relevant factors that served to shape the decision-making process in Finland. In particular, the role of the local community is obscured by a national discussion of Finnish nuclear energy policy. The basis of social acceptance in Finland appears to rely on the local community just as much as it does on a DiP from Parliament given their veto over the siting process and their role as a potential investor in the project itself (Tuohimaa pers. comm.). A more in-depth study of the role of local community at the municipal level might highlight other elements of the debate not captured in this analysis. A focus on the local political dimension in conjunction with a more detailed exploration of the underlying political culture that continues to show deference to expertise and political authority might prove quite fruitful in uncovering the unique features of the Finnish case. While there is a body of literature that explores the stability of the elite-driven corporatist decision-making model in Finland (Pelkonen 2008; Ruostetsaari 2009; Ruostetsaari 2010; Ruostetsaari 2013), it only scratches the surface. There appears to be a wide range of underlying factors, ranging from persistent power structures, to public trust in a centralized decision-making apparatus that are present in the Finnish case that, from afar, seem anachronistic to a modern western democratic state. A richer understanding of their history and

political culture might help to better explain this context which is left mostly untouched by the analysis presented in this dissertation.

Another notable omission that became apparent through a closer examination of the Finnish case was the role of Russia within the Finnish energy debate. Russia has long been used as a foil for Finnish policymakers when making appeals to the public regarding energy security. It is a dog-whistle meant to instill fear and play off their anxieties vis-à-vis Russia. The inclusion of Rosatom in the Fennovoima project added a wrinkle to this long-standing narrative, one that has been difficult to spin as a net positive for the Finnish consortium. The role of Russia in shaping Finnish energy policy is something that was not considered when this study was originally designed but it clearly warrants further study. Definitions of energy security that emphasize sovereignty often focus on concerns arising from dependence on suppliers perceived to be unreliable and/or adversarial (Cherp and Jewell 2011). The specter of Russia as an unreliable supplier of energy proved to be a regular trope used by Finnish politicians to justify the need for more NPPs during the OL3 debates (Hassi pers. comm.). The complicated relationship Finland shares with Russia is further muddled by Rosatom's participation in the Fennovoima consortium. It is now that much more challenging to discern exactly how Russia should be understood in the context of Finnish energy policy.[303]

Finland provides us with a case where energy security and environmental security have certainly been influential as fodder for political rhetoric but do not necessarily tell

[303] Satu Hassi notes that Russia has been used as a political boogeyman when convenient to do so, and later ignored when it was viewed as a political liability. Hassi asserts that it was the same politicians who campaigned against dependence on Russia during the 2010 DiPs that voted in favour of the new permit that included Rosatom in 2014. She lamented "that [this was] one of the big inconsistencies in Finnish politics" (Hassi pers. comm.).

us the whole story. I argue that the more substantive drivers in the case of Finland have been: high energy demand, strong political and financial support for nuclear power from Finnish heavy industries in conjunction with reliable political support from the Finnish Government. The strength of this coalition, in contrast to the ineffective opposition mounted by civil society, has ensured that Finland will continue to rely on nuclear power for decades to come. That being said, these decisions can always be revisited, delayed, and/or reversed.

Industry seized on a window of opportunity in the early stages of the so-called nuclear renaissance when it ordered OL3 in December 2003. In the early 2000s nuclear power was presented as a low-cost alternative that could be used to insulate Finnish industry from rising fossil fuel prices, and electricity imports from Nord Pool and Russia. With Finland committing to ambitious emissions reductions through the *Kyoto Protocol*, OL3 was promoted as a technological shortcut to assist in the transition to a low carbon economy. The successful Posiva DiP in 2001 all but guaranteed that OL3 would be able to overcome the obstacles that had frustrated earlier efforts to build a new reactor in Finland.

It remains to be seen whether the conditions that made Finland a politically permissive environment for nuclear power expansion during the last 15 years will persist into the next decade. The Fennovoima ownership scandal seems to have tested the patience of the newly elected Prime Minister Juha Sipilä and his Coalition Government. The Prime Minister has suggested that the Fennovoima plant may be the country's last new build, while also making clear "that no firm decisions had been made on the issue" (YLE 2015a). While Sipilä had campaigned on a similar position during the 2015

election, the fact that he repeated it in midst of the Fennovoima ownership scandal might be interpreted as a warning to industry for how his government would treat future DiP applications. Suffice to say that future applications will likely be scrutinized more heavily, particularly if they rely on foreign financing or ownership.

Table 6: Finnish Case Study: Factors for a State Expanding its Nuclear Capacity

Hypotheses	Outcome as Expected? (Yes/No/Unclear)	Evidence
Government Support for Industry	Yes	• Four DiPs in nine years (2001-2010), plus the amended DiP in 2014, in favour of nuclear projects suggests strong government support for industry. • The Posiva DGR had almost unanimous support in Parliament for its 2001 DiP.
Relationship Between Regulator & Industry	No	• There have been well-documented challenges between STUK and Areva which have led to delays at the OL3 plant.
Communication on Nuclear Power from Industry & Government	Unclear	• The nuclear industry in conjunction with the Finnish Government were able to make a compelling case for a fifth NPP that linked economic development and reduced emissions with the construction of OL3. • Difficulties encountered at OL3, in conjunction with financing/ownership issues of Fennovoima have damaged nuclear power's reputation in Finland, but to what extent remains unclear. It may make future public engagement campaigns more challenging for industry.
Effectiveness of Environmental Groups	Yes	• Finnish environmental groups were not able to effectively get their messaging out to the public using traditional media during OL3 DiP. • They have traditionally had limited access to Finnish policymakers and the decision-making process.
Public Support	Yes	• Public support for nuclear power has been relatively stable in Finland since the 1980s (~40% in favour) (NEA 2010). • The Finnish public tends to support the regulator and the government and does not appear to be all that engaged in the process.
Technical Barriers, Economics & Financing	No	• Many technical challenges were encountered by Areva at OL3 related to a FOAK design. • TVO could not support the cost of building OL4 due to cost overruns and challenges experienced at OL3. • Fennovoima struggled to secure domestic investment in spite of using the Mankala Principle and lost many key investors since 2012 including E.ON Nordic.
Waste Management Plan	Yes	• There were clear linkages made by industry and Finnish politicians to justify support for the Posiva DGR that were then reiterated during the 2002 and 2010 DiPs for new capacity. • The Posiva DiP helped to secure a positive result for OL3 in 2002 compared to 1993 when waste plans were still in flux.
Perception of Supplier & Related Financing Arrangements	No	• Rosatom has encountered public relations challenges since it became both the supplier of the reactor and an investor in the Fennovoima project. • A palpable degree of unease and discomfort has been shown over the level of Russian investment in the Fennovoima project by both the Finnish Government and the national media outlets.

A State Opting to Maintain: Canada

Canada is a country with 50 years of experience operating commercial nuclear reactors. Today, there are 19 reactors operating in two provinces providing approximately 16 percent of the country's supply of electricity. This dissertation focused on the province of Ontario where the vast majority of Canada's nuclear capacity is located. During the period of study, the Government of Ontario sought bids for the construction of two new units at Darlington on two separate occasions, before deferring the decision indefinitely. Instead, the province opted to refurbish ten of their existing reactors. As a result of this decision, the province is maintaining nuclear power as a core part of their supply mix, but with no immediate plans for construction of new capacity.

Eight factors thought to be relevant to the decision-making process were advanced by this thesis. It was expected that in the case of a state opting to maintain their nuclear capacity: (1) support for the industry and its development would be limited or inconsistent over time from the provincial and/or federal government; (2) the onerous regulatory requirements for new construction would dissuade utilities from pursuing new builds; (3) industry communication with the public and policymakers would have a mixed record of success conveying the benefits of nuclear power (i.e. nuclear power's role in combatting emissions would be contested or not clearly endorsed by the public); (4) environmental groups and those opposed to nuclear power would have had some success stymieing new projects; (5) the public would be ambivalent about nuclear power providing neither strong support nor strong opposition to the technology; (6) there would be issues associated with a new build related to its high capital costs; (7) a waste management plan would still be under development, hurting the prospects for nuclear

expansion; and (8) the restructuring of, AECL, a central player in the Canadian nuclear supply chain, would hinder the development of new projects.[304]

Like the Finnish case, while many of these factors were present, they did not have the effect(s) that I had initially anticipated. For example, the relatively slow development of a national waste management plan by the NWMO was not cited as a factor in the decision-making process to defer new construction or to refurbish existing capacity in Ontario. While the issue continues to draw the ire of opponents of nuclear power, it does not appear to be as influential as the literature would suggest amongst the public or policymakers in case of Ontario (Darst and Dawson 2010).

Similarly, the highly regulated nature of the nuclear industry and the onerous requirements for a new project do not appear to have had any discernable effect on the decision-making process in Ontario. Initially, my thinking had been that if regulations on industry were too arduous, refurbishment might be seen as the path of least resistance when compared to the Herculean task of getting a new reactor approved. To my surprise, industry participants were unanimous in their rejection of this hypothesis. They were keen to emphasize the good relationship they had with the CNSC, and the effectiveness of the current regulatory environment in supporting safe operations. So, what does this really tell us about the factors that shape a country's decision to maintain their nuclear capacity today?

First, economic considerations were particularly salient in this case. Put simply, the cost of refurbishment was far more palatable than that of new construction in the case

[304] The restructuring of a utility company or other key player in the industry would be expected to have a similar effect on the nuclear development of another country.

of Ontario. Cost considerations, in conjunction with lower than expected electricity demand, made the decision quite straightforward for the Ontario Ministry of Energy. The NEB has suggested that while electricity demand in the province will begin to recover by the year 2040, that it is likely to be lower than levels seen in 2008 (NEB 2016). The loss of demand triggered by the 2008/2009 recession, along with the rapid adoption of renewables in the province, makes the expansion of nuclear power exceedingly unlikely in the years to come.

Industry appears to have missed its window of opportunity to add new capacity in Ontario. The high demand experienced in the province from 2005 to 2008 made new builds a sensible option for a grid already highly reliant on the technology as a key source of electricity. By 2013, it had become increasingly apparent to policymakers that a weakened manufacturing sector in the province could no longer support such costly long-term investments in electricity generation.

Another important consideration in the case of Ontario is the consistently strong support the industry has received from the province during the period of study. Today, the province is poised to begin work on a planned $26 billion refurbishment of 8500MW at Bruce and Darlington that is expected to keep the province's reactors operating beyond 2060. The 2013 LTEP reflects a commitment to maintaining nuclear power as a key part of the province's supply mix for decades to come. OPG and the province have preserved the ability to revisit the question of a new build at the Darlington site, but there are few signs that this option will be exercised in the near term. Ontario's commitment to nuclear power beyond this round of refurbishment will depend heavily on whether a business case can be made for such a substantial public investment.

By contrast, the Federal Government's support for nuclear power expansion during this period was far less robust. The unwillingness of the Federal Government to underwrite some of the risk associated with building a FOAK NPP at Darlington was a key factor in the province's decision to defer plans for new units. The Federal Government had traditionally played a central role in providing support to the industry through its ownership of AECL. In partnership with Ontario Hydro, the predecessor to OPG, AECL had played a pivotal role in the development and construction of the province's entire nuclear fleet. The 2009 bid not only forced AECL to compete with international vendors like Areva and Westinghouse, but it had to do so with the looming specter of the Crown Corporation being restructured. While the McGuinty Government in Ontario had been prepared to work with their federal counterparts to negotiate a better price, there was little appetite from Ottawa to engage on this issue. In part, the unwillingness of the Federal Government to enter further negotiations on the Darlington project can be attributed to the AECL restructuring process.

The Federal Government felt that they had already made a significant contribution to the project through R&D spending on the ACR-1000, and were not interested in providing additional subsidies to AECL or the province to support the project. They wanted AECL to demonstrate that it could create a business case for the sale of the reactors that would not require further federal subsidy. The Federal Government did not want to take on any additional liabilities ahead of the sale of the AECL Reactor Division to SNC-Lavalin. This put any deal with Ontario on hold to allow SNC-Lavalin to assess the business case for the project on its own merits. The province had hoped that a competitive bid would serve to drive down the price of a reactor from AECL and entice

the Federal Government to financially support the project, but their plan failed on both counts.

Support for the nuclear industry was not tested from 2011 to 2013 as a result of the drop in forecasted demand for the province announced in the 2013 LTEP. It is unclear what, if any, federal support would exist for SNC-Lavalin or the Canadian nuclear supply chain should a new build be reconsidered in the near term.

This dissertation spent a considerable amount of time exploring issues surrounding social acceptance of both nuclear power as well as plans for nuclear waste management in Ontario. It looked at how the question of social acceptance has been advanced by environmental groups and the response that it elicited from both industry and the regulator. The heated battles over EAs and nuclear waste can be seen an indication of a growing discontent over how these decisions are being managed by policymakers, the regulator, and industry alike. There are signs from the Federal Government that more work needs to be done by industry and the regulator to restore public trust in the process. This is highlighted by the current federal review of the EA process and the recent Expert Panel Review. How the CNSC and the industry decide to cope with this kind of change could have significant consequences for Ontario's nuclear future.

The regulator continues to insist that social licence is not part of its mandate and asserts that industry should be the one conducting more robust stakeholder engagement. The nuclear industry, for its part, has been slow to adapt to the increasing demands from the public for greater transparency and more effective communication. Industry will need to find better ways of engaging with its opponents if it wishes to avoid damaging public

relations battles with civil society groups. Their current strategy has not closed the door on new builds in Ontario, but it risks doing so if public opposition to the technology is not adequately addressed in the near term.

Table 7: Canadian Case Study: Factors for a State Maintaining its Nuclear Capacity

Hypotheses	Outcome as Expected? (Yes/No/ Unclear)	Evidence
Government Support for Industry	Yes[305]	• Stakeholders interviewed noted that Federal support for new reactors in Canada was waning during the restructuring of AECL. • There was an unwillingness on the part of the province to shoulder the risks associated with a new build alone. • The 2013 LTEP reflects the province of Ontario's continued support for refurbishment of its fleet. • IESO's purchase power agreement (PPA) with Bruce Power and the OEB's increases to regulated prices for Darlington are another manifestation of government support for refurbishment. • The Government of Ontario was seen to be providing more outward political support for nuclear power than the Federal Government during this period.
Role of Regulations	No	• No evidence was found to support this hypothesis. The regulatory environment is thought to be well-suited to adapting to new builds of different varieties should they be considered in the future.
Communication on Nuclear Power from Industry & Government	Yes	• Those interviewed noted that while the industry was good at communicating amongst themselves, they struggled to tell their story to the general public. • Industry communication efforts with the public are often fragmented and episodic, with a special focus on host communities.
Effectiveness of Environmental Groups	Yes	• Their mixed effectiveness is evidenced by their unsuccessful court challenge of the Darlington EA in 2014. • Environmental groups have had some success influencing the ongoing federal EA review process.
Public Support	No	• Nuclear support is relatively high in Ontario but considerably lower nationally (Innovative Research Group 2012).
Technical Barriers, Economics & Financing	Yes	• The Government of Ontario cited the high-cost of the AECL bid in 2009 as a reason for deferring the project.
Waste Management Plan	No	• Not cited as a factor in the decision-making process to refurbish existing capacity in Ontario. • The issue was cited in the Greenpeace et al. (2014) court challenge of the Darlington EA, but the case ultimately proved unsuccessful on appeal. • Waste did not appear to be a barrier to the Darlington new build project.
Restructuring of AECL (Domestic NPP Supplier)	Yes	• The Government of Ontario cited AECL restructuring as one of many justifications that influenced its decision to defer the Darlington new build project in 2009. • Restructuring was a priority for the Federal Government, dampening its interest in projects that might incur new long-term liabilities.

[305] The hypothesis had assumed government support would be inconsistent or limited from one or both levels of government. Given the divided support, it broadly conforms to the original hypothesis.

A *State Opting to Phase Out: Germany*

Germany is a country with almost 50 years of experience operating commercial nuclear reactors. Today there are only eight reactors operating in four *Länder*, with plans for all units to be shut down by 2022. During the period of study, Germany initiated the legislative process to limit operating licences for its commercial NPPs, and began the process of phasing out their use.

Seven factors thought to be relevant to the decision-making process for a nuclear phase out were advanced by this dissertation. It was expected that in a case where a state was opting to phase out nuclear power: (1) state support for the industry would be limited; (2) industry communication with the public and policymakers would be non-existent or ineffectual; (3) environmental groups would have successfully framed nuclear power as a problematic technology whose risks outweighed its benefits; (4) the public would actively oppose nuclear power and support the phase out; (5) waste management plans would have proven to be contentious and unresolved; (6) nuclear power would not be viewed as a suitable technology for reducing emissions; and (7) plans for the phase out would not be seen as likely to lead to serious technical challenges (e.g. to lead to disruptions of supply) or be associated with insurmountable costs thought to make the process prohibitively expensive. Given that a phase out would be a political decision, the role of the regulator was expected to be less relevant. It was also assumed that economic considerations like the relative costs associated with new builds versus refurbishments would not play a significant role in the decision-making process.

In this case, while there was evidence to support all of the expected outcomes, there were certain factors that proved more influential than others. Some of the hallmarks

of the German case included: the effective mobilization of the anti-nuclear movement, the growth of a successful Green Party (at the *Land* and federal level), and the inclusion of institutionalized counter-expertise within the regulatory process. While it was expected that an anti-nuclear movement would be effective in this context, I had not anticipated the strength or significance of the Green Party and/or the role of environmental think tanks in pushing for the phase out. Taken together, they helped to build the momentum necessary to fundamentally alter the perception of nuclear power in Germany. The high political visibility they gave to the nuclear issue, in conjunction with their ability to keep it relevant for such an extended period of time, helped to facilitate a gradual political rethink of the technology's role within the German supply mix.

Throughout the 1980s, the Green Party's position on nuclear power gained traction amongst the political left, leading the SPD to gradually soften their support for the technology. While external shocks like the accidents at Chernobyl, and Three Mile Island, alongside issues like US missile deployments undoubtedly had a significant influence on the German public's view of nuclear power, it was the Green Party that gave voice to those concerns. Post-1986, the Greens could reliably count on the SPD to be a strong advocate and coalition partner in the fight to phase out commercial nuclear power. The role the Greens played in initiating this shift on nuclear policy in German federal politics cannot be stressed enough.

A closely related factor to consider is the importance of coalition politics in Germany, and how the political environment forced federal parties to adapt their positions over time in order to find partners willing to form government. Following the 2013 collapse of the FDP, the CDU/CSU's traditional ally, they needed to be able to

work with the SPD or Greens in order to form government. The CDU/CSU's unwavering support for nuclear power had in the past made collaboration with the Greens a non-starter. Merkel's willingness to abandon this longstanding policy at least opens the door to a Black-Green Coalition, should a Grand Coalition prove untenable (Rüdig 2014).

The ability of environmental think tanks to establish themselves as a credible source of counter-expertise on nuclear power was another important factor in shifting the political discussion on the technology in Germany. More to the point, their access to government officials and to regulatory processes sets the German case apart from the others. This is evidenced by their inclusion in expert commissions like the Gorleben International Review, the 2011 Ethics Commission, the HLWC, and others discussed throughout this dissertation. The German decision-making framework provided greater opportunities for diverse opinions to be heard within public policy debates. It allowed for a more holistic approach to safety and risk to be brought forward, one that sought to better reflect the non-technical concerns of the public as it related to nuclear power in Germany. This approach was far more responsive to the public than any other model explored in this dissertation, extending well beyond the environmental assessment process as we saw in the Canadian context.

In addition to the strong role of the Green Party, German coalition politics, and environmental counter-expertise, another factor that had not been adequately captured by the original parameters of this study were the lengthy historical battles already fought over nuclear expansion, reprocessing, and waste. The political stage was in many ways already set for the Red-Green Coalition to negotiate the terms of the phase out during their first term in office (1998-2002). Similarly, the political climate was such that by

2010, the decision by the Merkel Government to extend reactor licences could not reverse the phase out; instead, it could only delay it. Nuclear power had been effectively transformed from an essential tool needed to help modernize and rehabilitate the German economy during the 1970s and 1980s, into a necessary evil only to be tolerated as a bridge technology until renewables were mature enough to replace it. The German public was reticent to accept nuclear power as a bridge technology prior to the Fukushima accident and outright hostile to it afterwards. Nuclear power had become, for all intents and purposes, politically taboo in Germany. This dissertation sought to demonstrate that the decision to phase out the technology was not a knee jerk reaction made in the immediate aftermath of Chernobyl or Fukushima. Instead, it is best characterized as a gradual process, negotiated over a protracted period of time, that culminated in a policy for a low carbon future that excluded nuclear power: the German *Energiewende.*

When I first began researching the issue, I hypothesized that the phase out might be seriously challenged by large increases in electricity costs associated with the transition away from nuclear, and the potential damage it might do to the German economy. What quickly became apparent through interviews with a variety of stakeholders, was that the costs associated with a phase out were not a primary concern for decision-makers, nor was the welfare of the German utility companies. While most if not all acknowledged the challenges associated with the phase out and the *Energiewende*, it was consistently framed as a policy that had already been finalized and was no longer up for debate. There is no indication that the phase out will be reversed in Germany.

The tensions on display following the 2010 decision to extend operating licences was but the last salvo in a hard-fought political battle over nuclear power's future in

Germany. The June 2011 decision to amend the AEA and expedite the phase out surprised no one, and would gain almost unanimous support amongst politicians and the public alike. While there remained unresolved issues over how costs would be shared related to the phase out (i.e. waste and decommissioning), there were no longer any indications that the policy would be delayed or reversed.

Table 8: German Case Study: Factors for a State Phasing Out its Nuclear Capacity

Hypotheses	Outcome as Expected? (Yes/No/Unclear)	Evidence
Government Support for Industry	Yes	• The 2000 agreement between the Federal Government and the German utility companies signaled an end to federal support for nuclear power. • No significant reversal of this policy was witnessed thereafter, nor is one anticipated.
Communication on Nuclear Power from Industry & Government	Yes	• No evidence was found to suggest that communication by industry or the government was effective with the public. • There were large protests in response to the Merkel Government's 2010 Energy Concept and the framing of nuclear power as a "bridge technology." • There was also strong opposition to granting licence extensions to German NPPs.
Effectiveness of Environmental Groups	Yes	• Environmental groups were effective on many fronts, namely: mobilizing public support, disseminating counter-expertise, and gaining access to policymakers through expert commissions and regulatory bodies.
Public Support	Yes	• Public opinion data has consistently shown decreased support for nuclear power since the mid-1980s. • Large protests have been another manifestation of anti-nuclear sentiment amongst the German public.
Waste Management Plan	Yes	• Political battles over Gorleben and Castor transports for over four decades have been a regular flashpoint for anti-nuclear sentiment in Germany. • Unresolved issues surrounding Germany's waste management held up the construction of NPPs during the 1970s and 1980s as a result of administrative court rulings. • Waste management continues to be a major roadblock as Germany moves towards a phase out.
Perception of Technology	Yes	• The German Green Party has actively rejected the idea that nuclear power could be used to combat emissions for decades. Today there is an all-party consensus on the nuclear issue. • Polling data indicates that Germans believe that the risks outweigh the benefits of nuclear power.
Challenges to Phase Out	Yes	• Neither the German public nor its policymakers have shown any serious concern over the costs associated with the phase out and/or the technical challenges that might arise during its implementation.

Cross-Case Comparison: Windows of Opportunity

Across the three case studies there are some lessons learned that help to highlight the key variables which serve to shape a country's policy towards commercial nuclear power. The decision to maintain, expand, or phase out the use of commercial nuclear power is more than just a question of how much the project will cost relative to the alternatives.

In the cases of Canada and Finland, we see two governments that are relatively supportive of the technology achieving very different outcomes. Given the long lead times involved in the planning, licensing, and construction of a reactor, it is perhaps not all that surprising that there are multiple policy junctures where a nuclear trajectory might be obstructed, altered, or entirely reversed. There are factors that can present windows of opportunity for expansion that are somewhat precarious and may not hold over the long term. For example, had Ontario opted to build two new units in 2009, construction would likely have been well underway before the long-term effects of the recession could be properly assessed and internalized. From 2006 to 2009 Ontario presented itself as a case with many of the factors that are positively correlated with the expansion of nuclear power. They included: a high demand forecast for electricity, rising fossil fuel prices, political support from the provincial government for the technology, and limited public intervention in the decision-making process. Unfortunately, limited federal engagement (as a result of AECL restructuring) and the high costs associated with the ACR-1000, left the province weary of taking on the risks associated with a FOAK reactor. That being said, one could easily imagine a counterfactual in which a more competitive bid from

Areva or a deal struck with AECL and the Federal Government might have led to a very different outcome.

In the Finnish case, it is easy to imagine a scenario in which Fennovoima's application to amend their DiP could have been rejected by Alexander Stubb's Government in the fall of 2014.[306] The project could also have become derailed in the summer of 2015 had the consortium been unable to find sufficient Finnish investment to meet the requirements of their amended DiP. Instead, the Finnish Government provided Fennovoima the time needed to strike a deal with Fortum, and a handful of other investors in order to salvage the project. Similarly, OL3 could have been abandoned at multiple junctures along the way, given that it is now nine-years behind schedule, and more than €5 billion over budget (Ward 2017; WNA 2017g). In neither case was it necessarily guaranteed that the operator could overcome the political and financial hurdles that befell them.

These are but few examples of critical junctures where the pendulum could have swung the other way and led to either the approval or the cancellation of a nuclear project. The long lead times associated with these projects ensure that there are multiple opportunities to change course and potentially reverse a positive decision.[307]

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[306] The amended DiP was required to allow Rosatom, a Russian state corporation, to replace E.ON Nordic within the Fennovoima consortium. It was also required to amend the design of the reactor being proposed for the project.

[307] The Finnish experience demonstrates that it can take over 15 years to get a proposed reactor built. In the case of Fennovoima, the original DiP application was submitted to Parliament in 2009. Construction is not expected to start until late 2018, with the reactor coming online no earlier than 2024 (WNA 2017g). In the case of OL3, it will have taken 20 years to go from its initial EIA submission through to commercial operation assuming it comes online in 2018.

This dissertation argues that windows of opportunity for nuclear expansion tend to present themselves when: government support for industry is strong, political opposition is weak or ineffective, and economic growth considerations are able to dominate the political narrative. In the case of Finland, government support was driven in large part by an overriding concern with developing and maintaining a competitive advantage in export-driven sectors like forestry and steel.[308] While there was opposition from the Green League and environmental groups in Finland, they proved ineffective in blocking DiPs in Parliament and/or mobilizing a substantive backlash to the nuclear expansion amongst the public.

While a similar approach to decision-making served to facilitate earlier periods of expansion in countries like Canada and Germany, over time there has been an increasing trend towards greater public engagement. This increased level of public engagement has led to greater scrutiny of these projects, and in effect closed the window of opportunity for nuclear expansion. For Germany, that window of opportunity was effectively closed by the late 1980s. For Ontario, it is unclear whether the window has firmly shut, however, there is no clear path to new construction post-2013.[309]

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[308] Industry support for the technology can also be an important factor in determining whether more capacity will be built. Finland's use of *Mankala* companies demonstrates a strong commitment to nuclear power from Finnish industries as evidenced by their willingness to invest directly in new capacity.

[309] While Ontario is working to maintain its site preparation licence for new capacity at Darlington, there are no new reactors planned at this time, nor is demand likely to warrant them. Utilities in Ontario, Alberta, Saskatchewan, and New Brunswick have continued to signal an interest in new NPPs, particularly for small modular nuclear reactors (SMRs), however the technology is still in the early stages of development (RNNR 2017; Senate of Canada 2017). Vendors would still need to demonstrate that SMRs are deployable and cost competitive with existing alternatives. There would also likely be a need for some regulatory reform to adjust regulations to reactors of this size. There are a variety of initiatives underway to assess the challenges the technology might

Increased public engagement in the realm of energy policy planning has historically coincided with a slower approval process that has served to frustrate the development of proposed nuclear projects. We see elements of this transformation taking place right now in Canada as evidenced by legislative reform of Ontario's LTEP to one that requires greater public consultation. There is also a push at the federal level to revisit CEAA 2012 to make EA reviews more inclusive and transparent. While it is too soon to assess the long-term impact of these kinds of changes, early indications suggest that greater consultation could serve to significantly delay major infrastructure projects, if not derail them entirely. The long delays experienced by proposed oil and gas pipelines show just how challenging the political climate has become for large-scale energy projects (Reed et al. 2016).

However, it should be noted that increased public engagement is not the only consideration when assessing whether a project will encounter strong opposition. The strength of civil society, in conjunction with the growth of green political parties, plays an important role in determining just how effective opposition to nuclear power will be.[310] They challenge the narratives presented by proponents of nuclear power, while raising ethical and moral considerations that go beyond purely technical assessments of risk and utility. The German case is instructive, as it shows just how embedded these

face in the near term should it be developed and deployed in Canada (see for example, CNSC 2016a; CNL 2017).

[310] It is worth noting that the Green League in Finland has been part of multiple governing coalitions. While the Greens actively opposed new reactor construction in Finland, they did not have the votes necessary to prevent DiPs from being passed. The Greens ultimately left Paavo Lipponen's Government in 2002 over the OL3 DiP. They also left the Alexander Stubb's Government in 2014 following the decision to accept an amended DiP for Fennovoima.

actors can become within the decision-making process. There we saw an ethics commission achieve a greater degree of influence over the decision to expedite the nuclear phase out than a technical study of reactor safety conducted by the regulator.

This dissertation's findings confirm the literature's claim that nuclear expansions are most likely to take place within governance models that are centralized, technocratic, and involve limited public engagement (Thomas 1988; Slovic 1993; Campbell 1988; Jasper 1990). As decision-making shifts away from being centrally planned and technically-informed by experts to a more democratic process, an increased emphasis on social considerations will likely cause large-scale infrastructure projects like NPPs to become much more challenging to advance (Morone and Woodhouse 1989). Taken together with the rising costs of new nuclear construction, it will greatly limit where new construction will seriously be considered. Ultimately, even when policymakers are supportive of the nuclear industry and are intent on expanding capacity, a variety of factors can lead to inaction, causing a state to chart a different course.

Windows of Opportunity: Points of Vulnerability and Veto

As noted in the previous section, these windows of opportunity can be quite precarious in nature. Given the long-lead times associated with the construction of NPPs, there can be multiple points of vulnerability which can serve to hurt the viability of a given project, or potentially cancel it altogether. Beyond the individual factors listed in the previous section, it is important to consider what combination of factors might work together to create and sustain these windows of opportunity, and what might serve to challenge them. Part of this question depends on where these decisions are made and who is included in this process.

In the case of Finland, decisions about new capacity are voted on in Cabinet and then again in Parliament as part of their DiP process. While the government receives technical advice from the MEE, the decision remains largely political. Environmental groups can mount campaigns to challenge DiPs for nuclear projects, however the Finnish nuclear industry has shown considerable success in marginalizing these opposition groups (Berg 2009). Well-funded *Mankala* companies like TVO and Fennovoima, were able to capitalize on a period when concerns over emissions were high and nuclear waste was low. Finnish industry also benefitted from a political culture that favoured a market-oriented corporatist approach to governance and discouraged protest and dissent. While the Finnish regulatory process included public hearings, decisions on energy policy and nuclear power remained largely "a closed process of deliberation and negotiation between the privileged stakeholder groups" (Pelkonen 2008: 404). Civil society groups and political parties like the Green League were perceived as outsiders that lacked objectivity, and were seen to be promoting their own political agenda. Taken together, the structure of Finnish decision-making limited the access of would be opponents of nuclear power, and insulated policymakers from alternative views on the issue.

Once a DiP was approved, the real points of vulnerability were economic in nature. Examples of this include the cost overruns and delays experienced at OL3 and the ownership issues with the Fennovoima project. In the case of Fennovoima, it was particularly problematic because the Finnish Government threatened to block the construction permitting process if the domestic ownership criteria were not met. By contrast, the points of vulnerability in the Canadian case were slightly different.

In the Canadian case, the provincial government is ultimately responsible for deciding its own supply mix, while the federal government regulates all aspects of the technology. Put simply, the province is responsible for deciding to build, refurbish or phase out the technology, but the regulatory process for whether a specific project is approved remains federal. In the case of Ontario, the decision to build additional capacity or refurbish existing ones comes from the Ministry of Energy and is not voted on in the legislature. While there are public consultations on policy documents like the LTEP, their influence to date has been quite limited.

The first major point of vulnerability for the Darlington project was the province's need for federal financial support. While AECL was able to provide a compliant bid for two new units at Darlington, the price was too high for the province to shoulder it alone (Cadham 2009). With plans for restructuring already underway, there was a reticence on the part of the Federal Government to assume new liabilities for such a capital-intensive project. This for all intents and purposes put plans for the expansion of nuclear capacity in Ontario on hold. It remains to be seen if a nuclear project could be built in Canada without some level of federal assistance.[311]

The second point of vulnerability observed in this study took place during the federal licensing process. Environment groups acting as intervenors used the legal system to challenge the EA process when their initial interventions proved unsuccessful. Court challenges to the licensing and siting of a facility are likely to persist for future projects and are not unique to the nuclear sector. The federal EA process has been identified by

[311] A state-owned foreign vendor could offer this kind of support should Ontario decide to revisit the project in the future. This support might include generous financing and loan guarantees as we have seen in the case of Finland.

others as "the principal source of delay and unpredictability in the Canadian project approval process" (Reed et al. 2016: 342). Given the ongoing federal EA review process, there is an added element of uncertainty as to how the process will be navigated moving forward. Increased access to public hearings for intervenors in conjunction with more robust indigenous consultations are likely to accentuate this vulnerability, rather than mitigate it. Certainly, this was the case in Germany, when environmental groups increasingly began to embed themselves into the regulatory process.

It is worth noting that STUK's regulatory reviews have not been a point of vulnerability for the industry in Finland.[312] In part, this is due to the high-level of trust the Finnish public has in science, expertise, and technocratic decision-making (Teräväinen et al. 2011; Ruostetsaari 2013).[313] The factors that promote this political culture are beyond the scope of this dissertation, however certainly merit further study.

A third point of vulnerability in the case of Ontario has been largely driven by changing market conditions. The slow recovery from the 2008/2009 recession has kept demand for electricity flat, reducing the need for new capacity. This in conjunction with the growth of renewables has hurt the business case for new builds in Ontario. Electricity demand in conjunction with the cost of alternative sources of energy will continue to be a serious point of vulnerability for any new nuclear project in the province. Market conditions will also influence how many units are refurbished in Ontario. The 2013 LTEP

[312] Regulatory delays have adversely affected the OL3 project, but these have been principally driven by FOAK design issues.
[313] This stands in contrast to a recent report which found that Canadians lacked confidence in the federal EA process (Gélinas et al. 2017).

built in "off-ramps" to provide the province the flexibility to cancel projects no longer deemed necessary or cost-effective should market conditions shift over time.

In the case of Germany, the points of vulnerability were not economic or market-driven like Finland or Canada. Like Canada, they began with the regulatory process but have since been extended to include the political arena. In Germany, nuclear regulation and energy policy is created at the federal level but implemented by the *Länder*.[314] As one might imagine, the implementation of a national policy has tended to be smoother when both levels of government are governed by the same party (or share the same view on a particular policy area), however, this does not guarantee the smooth siting of a NPP. For example, while the Government of Baden-Württemberg supported the federal energy policies of the 1970s that encouraged nuclear expansion, state-level support could not quell local opposition to the siting of a NPP at Whyl. This included large public demonstrations and occupation of the construction site, followed by legal challenges used to stall the project (Hatch 1986). Similar conflicts were repeated in Schleswig-Holstein and Lower Saxony, reflecting a growing unrest with the national energy policy. Early on, environmental groups were able to leverage the courts to obstruct the regulatory process, slowing the growth of nuclear power in Germany.

Gradually this point of vulnerability became more pronounced as environmental think-tanks began to embed themselves in the regulatory bodies themselves. Inclusion in

[314] While Canada and Finland have unified national regulators, Germany's regulatory environment includes federal regulatory bodies and advisory boards as well as licensing authorities at the *Land* level. A utility would have traditionally applied to the *Land* authority for a licence to build new capacity, however, no facility was licensed without "the consent of the BMI [a federal ministry]", a precursor to the BMUB (Hatch 1986: 72).

ad-hoc commissions like the 2011 Ethics Commission and advisory bodies like the RSK have ensured that they not only have access to these regulatory bodies, as they do in Canada and Finland, but more importantly, that they also have influence over the process. This point of vulnerability extended the political sphere with the emergence of the Green Party in Germany. Their inclusion in governments at the *Land* and federal level increased the visibility of the nuclear issue and ultimately helped them initiate a political phase out of the technology. Their ability to find a willing partner in the SPD, an established political party, and work with them over a protracted period of time, provided the Greens the opening needed to gain influence within the German political system and exploit it to their advantage.

Lastly, nuclear waste has served as a key source of vulnerability in the German case. This the anti-nuclear movement was able to use large demonstrations and legal challenges to limit spent fuel shipments and block the siting of a HLW DGR (i.e. Gorleben). Alexander Glaser (2012) asserts that the anti-nuclear movement was able to transform the otherwise mundane industrial practice of fuel shipments into a national media spectacle. The increased political visibility of the issue ultimately helped opponents of nuclear power to extract concessions from industry during the phase out negotiations (Rüdig 2000). While waste issues were present across all three cases, Germany proved to be the only case where it could be effectively leveraged to truly wound the nuclear industry.[315]

[315] The Green League in Finland did have some success pushing for reform on Finnish waste policy during the 1990s. In particular, they succeeded in putting an end to spent fuel shipments to Russia from the Loviisa plant. However, following the DiP for the Posiva DGR in 2001, the waste issue lost its salience in the Finnish nuclear energy

Facilitating Conditions Across Cases

What we see from the above analysis are a few central issues that help to shape the nuclear trajectory of a given country. In addition to the broader findings that nuclear expansion is most likely to take place within governance models that are centralized, technocratic, and with limited public engagement, there are facilitating conditions we see across the three cases. They include access to and influence over policymakers, energy security considerations (including market conditions), and political visibility.

Those with privileged access to and influence over policymakers will in many ways help to determine the level of support a government will have for nuclear power. When discussions are limited to industry stakeholders and mainstream political parties, nuclear power is often framed in a positive light. Traditionally it has been presented as a technological solution to energy insecurity to be evaluated primarily on technical and economic considerations. These narratives only tend to get challenged when alternative parties and environmental groups gain greater access to and influence over the decision-making process.

In two of the three cases we have explored, we see green political parties who are able to gain representation in parliament and eventually join government. In part, this is due to electoral systems (mixed-member proportional systems) which favour the use of coalition governments. This has helped alternative parties in both Germany and Finland find success. By contrast, green parties in Canada (at the federal and provincial level) have struggled to navigate the first-past-the-post electoral system which tends to favour

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debate. For a discussion of the evolution of Finnish nuclear waste policy see, (Darst and Dawson 2010).

established political parties (Norris 2004; Duverger 1954).[316] In Ontario, they have yet to elect candidate to the provincial legislature, while at the federal level they only have one MP elected to the House of Commons.[317] That being said, having access to government is not the same as having influence over the policymaking process. In Finland, Green League MPs have lamented that their views on nuclear power are not always taken seriously, even when in government. This was highlighted by the 2002 OL3 DiP decision that led the Greens to leave the Lipponen Government. They also left the Stubb Government in 2014 following the decision to accept an amended DiP for Fennovoima project. In both circumstances, they could not act as veto players to block the DiP. George Tsebelis (2000: 442) defines veto players as "individual or collective decisionmakers whose agreement is required for the change of the status quo." In this case, the Green League had neither the votes needed to control the agenda nor the ability to get the others to acquiesce to their political preferences on nuclear power.

The same logic can apply to environmental groups who have access to regulatory processes. In all three cases, environmental groups have access to regulatory hearings,

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[316] Pippa Norris (2004: 44) contends that "green parties…usually have shallow support spread evenly across multiple constituencies…" which makes their candidates less viable in electoral systems that require votes to be concentrated in specific territorial constituencies. Majoritarian systems like first-past-the-post tend to favour a two-party system (Duverger 1954). While Canada's electoral system has historically produced more political parties, only three presently have official party status.

[317] In the 2014, the party garnered 4.8 percent of the popular vote, but failed to elect a single candidate to the legislature (Ferguson 2017). Elizabeth May, the leader of the Green Party of Canada, is the only member of her party with a seat in Parliament at this time. The 2017 provincial election in British Columbia led to formation of a minority NDP Government supported by the Greens, the first of its kind at the provincial or federal level in Canada (ibid.). It remains to be seen how stable this political arrangement will be or whether it is a harbinger for greater success for the Green Party in other parts of the country.

but only in Germany have they truly gained influence over the process. Simply having access to the process as an intervenor does not grant you the same level of influence as an expert on a regulatory body as we have seen in the German case. Access to and influence over the decision-making process can cut both ways. It can facilitate expansion as well as help to support the phase out of nuclear power, depending who is ultimately able to wield the most access and influence over the decision-making process.

Another facilitating condition we see across the cases is the role of energy security, including general market conditions. It can serve to both support as well as frustrate a nuclear project. For our purposes, energy security consists of three dimensions: availability, affordability, and acceptability (Hughes 2012). Policymakers must consider the ability of the existing supply mix to meet future demand in a cost-effective manner while making every effort to reduce emissions. They must also take into consideration preferences that might exist for alternative sources of energy (e.g. renewables over nuclear power or coal).[318]

In the case of Finland, it is a country that is highly reliant on energy imports, providing an added impetus for building large-scale generation capacity.[319] Costly imports from Nord Pool and Russia haver served to incentivize investment in NPPs. In

[318] A preference for affordable and readily available sources of electricity may not be compatible what is environmentally friendly. Similarly, an energy source deemed to be socially acceptable may not be the most cost-effective option. "Trade-offs often occur between technologies and policies that are effective along one dimension but adversely impact other aspects of energy security. Countries often choose options that involve progress in one energy security domain by eroding another" (Sovacool and Brown 2010: 103).
options that involve progress in one energy security domain by eroding another.

[319] Finland currently imports a little over 22 percent of its electricity needs (Finnish Energy 2017).

this case we see high energy demand, reliance on electricity imports, encouraging industry-driven consortiums to invest in nuclear, in conjunction with consistently high-levels of state support, combining for a persisting window of opportunity. Finnish advocates for nuclear power were able to frame the technology as the best option available for meeting the country's electricity needs, while also reducing its emissions. In the case of Ontario, its phase out of coal facilitated the decision to refurbish existing nuclear capacity, however, flat electricity demand, in conjunction with the rapid development of renewables served to dampen interest in new builds. The market conditions in Ontario have made nuclear expansion difficult to justify given the available alternatives.

In the case of Germany, it continues to be a net exporter of electricity, even after shutting down nine of its NPPs. Its supply mix has benefitted from the growth of renewables and the continued use of hard coal and lignite (Fraunhofer ISE 2017; Carbon Brief 2016).[320] In this case, the surplus of electricity generating capacity in conjunction with the availability of domestically-sourced lignite and imported fossil fuels (hard coal and natural gas), have helped to facilitate the phase out of nuclear power.[321] Germany's relative energy security allowed it to advance its preference for renewables while still maintaining a healthy surplus of generating capacity. The cases explored in this

[320] Germany is highly reliant on gas imports from Russia, however it is used primarily for heating purposes as opposed to electricity generation (Amelang 2016; Zha and Shiryaevskaya 2017). Eight percent of Germany's electricity needs are currently met using natural gas (Fraunhofer ISE 2017).

[321] The German Government has a long and complicated history with the coal industry (Hatch 1986; Renn and Marshall 2016). In a country that still mines both lignite and hard coal, it has been difficult to reduce reliance on its use in spite of popular support for emissions reductions and the *Energiewende*. For a discussion of a possible coal phase out in Germany see, (Ruiz 2017).

dissertation show us how energy security can be used to justify nuclear expansion, as well as facilitate its maintenance or phase out.

Finally, political visibility can be another facilitating condition critical to the success or failure of a project. Cases of nuclear expansion and maintenance tend to benefit from reduced political visibility. When plants are operating safety and reliably, nuclear power is not generally viewed as contentious. Issues tend to arise when accidents occur abroad (e.g. Three-Mile Island, Chernobyl, and Fukushima), safety issues emerge at home (e.g. the fire at the Krümmel in Germany), and/or waste issues become politicized. Political visibility is not typically one incident, or media-cycle, but instead must be sustained over time. We see this in the case of nuclear waste in Germany, whereby sustained scrutiny and political visibility was given to the siting of DGRs, proposed reprocessing facilities, as well as shipments of spent fuel. In these cases, the technology becomes a target for public scrutiny, whereby it is politically contested and challenged. By contrast, nuclear power's political visibility has ebbed and flowed in Canada and Finland, keeping the issue from becoming unnecessarily controversial and politically charged. A lack of political visibility can provide policymakers greater flexibility to pursue policies that are more technically informed, with far less public scrutiny (e.g. the NWMO process in Canada or Posiva in Finland).

We see these facilitating conditions (political access and influence, energy security, and political visibility) combining in different ways to allow windows of opportunity to persist in some cases, while forcing them shut in others. They are meant help sensitize the researcher to factors that can play a prominent role in setting the stage for how these divergent nuclear trajectories take shape (i.e. the points of veto and

vulnerability). They provide some of the political and historical context needed to explain how we got to one policy outcome or another, providing the researcher a clearer picture of how these nuclear trajectories develop and mature.

The Ongoing Role of the State and the Potential for Unintended Course Corrections

Countries may initially intend to expand their fleet, but over time may unintentionally shift towards the maintain or phase out position without significant policy interventions to support the growth of the industry. If a country currently operating NPPs postpones making a decision about the future of their program, they may by default fall into the maintain category. I argue that since 2013 Ontario finds itself in this predicament.

If decisions regarding refurbishments are deferred too long, indecision might lead to an unintended phase out. Peter Bradford (2013) suggests that a similar level of government intervention is required to both maintain as well as a phase out nuclear power. In the case of the US, he observed that:

> Absent an extremely large injection of government funding or further life extensions, the reactors currently operating are going to end their licensed lifetimes between now and the late 2050s. They will become part of an economics-driven US nuclear phase-out a couple of decades behind the government-led nuclear exit in Germany (Bradford 2013: 13).[322]

Given the limited number of reactor sales in recent years amongst OECD countries, the maintain trajectory will likely become the most widespread. If states are keen to maintain their fleet as a tool to offset emissions, policy interventions will likely be necessary to ensure that incentives are in place to both maintain existing capacity and promote new

[322] He refers to this phenomenon as a "glide path" driven in large part by how long the US regulator will allow older reactors to operate, and the costs of maintaining aging plants compared to the alternatives (ibid.).

construction. It is important to note that subsidies for new construction have regularly been flagged as important to making nuclear competitive (Deutch et al. 2003) but they are equally important for incentivizing operators to maximize the lifetimes of their existing fleets. Policy levers in support of nuclear power can take different forms and need not be a production tax credit or direct subsidy.

In the case of Finland, state ownership still plays an important role in ensuring nuclear power remains a core part of the supply mix. Fortum, a state-owned utility, not only owns and operates two reactors at Loviisa but also has a critical ownership stake in both the Fennovoima and TVO plants. In Canada, while the Federal Government divested itself from the nuclear business, the province of Ontario remains highly engaged. OPG is a wholly-owned provincial crown corporation, which operates ten of the province's 18 reactors (six at Pickering and four at Darlington), and leases the province's other eight units to Bruce Power. It is also the only utility with a site currently licensed for additional capacity. To support the refurbishment of capacity at the Bruce site, IESO (under the direction of the Ministry of Energy) has amended its long-term contract with Bruce Power to ensure its capacity remains online through to 2064. OPG, for its part, has sought rate hikes from the OEB to make the refurbishment at Darlington financially viable, while extending the life of the Pickering units through to 2024.

In both cases we see the state and the province continuing to play a critical role in keeping nuclear competitive within so-called liberalized electricity markets. The era of vertically integrated utilities may have come and gone, but the importance of the state to the nuclear industry has not faded. These case studies confirm the central role of the state in maintaining and expanding nuclear power capacity in the twenty-first century. The

need for state intervention will likely persist, given the risks associated with long-term investment in new nuclear capacity and refurbishment. This phenomenon extends well beyond the cases covered within this dissertation.

We see the need for state subsidy and state corporations to facilitate the construction of new capacity in countries all around the world (e.g. UK, France, US, India, China, Russia, UAE, and Turkey). In the US, significant financial pressures are forcing utilities not only to seek production credits to keep reactors from early retirement, but also to ensure that the two reactors under construction can be completed following the bankruptcy of Westinghouse Electric (Bade 2017; Haratyk 2017; Maloney 2017; Shea and Hartman 2017). The role of the state in the nuclear sector has always been significant, however, the environment in which policy decisions are made has evolved over time. Further study of the tools available to policymakers during this period of gradual expansion may help to better understand how the role of the state is changing over time.

Contribution to the Literature

This dissertation sought to reorient the discussion on commercial nuclear power away from non-proliferation concerns to more salient features that defined the nuclear renaissance. For too long the discipline has focussed primarily on historical cases of nuclear expansion, and as a result incorrectly assumed that national security considerations remain a key factor in shaping decisions on nuclear energy policy (namely an interest in acquiring nuclear weapons). This study challenged those assumptions and sought to determine what factors shape contemporary policy surrounding commercial nuclear power development. To address some of the theoretical blind spots of the

discipline, this dissertation drew inspiration from security studies, economics, sociology, and the work done on risk perception to build on the existing nuclear power literature.

Given the limited number of cases, the findings of this dissertation cannot be viewed as conclusive. Instead they provide us with a starting place to begin to discern what variables are significant in determining a country's policy towards commercial nuclear power. This dissertation created a typology with three principle energy trajectories for states with existing commercial nuclear power programs as an analytical tool for helping to isolate and identify some of the key the factors that shape the decision to expand, maintain, or phase out the use of the technology. This study sought to better understand the factors that led to such divergent outcomes among similarly situated states since the year 2000. The focus was not on the drivers that led to the initial adoption of the technology but rather the ongoing policy affirmation(s) needed for a program to continue to operate and potentially grow during the period of study.

While no clear connection to the environmental dimension of energy security was established across the three cases, it was evident that questions that go beyond those of national security were shaping discussions on nuclear power. While one cannot entirely discount non-proliferation concerns, this dissertation has argued that they should not be at the forefront of the study of commercial nuclear power in the twenty-first century. Countries pursuing modern commercial reactors without the sensitive elements of the fuel-cycle (e.g. reprocessing and enrichment technology) force us to consider other motivations that might be at play.

Today questions of climate change and sustainability often dominate energy policy debates. While nuclear power offers a near emissions-free source of electricity, it

remains a controversial technology that can be viewed as risky and ill-suited to reducing a country's emissions. A country's unique experience with the technology and the perceived alternatives at their disposal will serve to shape their respective nuclear trajectory. When it comes to energy policy it is argued that "decisions about future energy supply cannot be easily divorced from the interests, values and perceptions of the people and communities which energy systems are ultimately meant to benefit and serve" (Corner et al. 2011: 4831).

This dissertation began with the premise that no single event, policy, or political constituency was solely responsible for the current energy trajectory of a given state. Using an inductive approach, it sought to demonstrate how these policies evolved over time, from various vantage points, through in-depth case studies that provided context to these complex nuclear histories. In no sense were the classifications set out in my typology of nuclear trajectories meant to be deterministic or fixed. Instead, they were meant to serve as a barometer or heuristic that helped the researcher to focus on how these trajectories took shape and to begin to better identify the causal conditions that led to their adoption.

What emerges from the case studies was a clearer understanding of the overarching features that make nuclear expansions more likely, and the points of veto and vulnerability that can serve to alter or reverse these trajectories. Growth in nuclear capacity tends to occur when governance models are centralized, technocratic, and limit public engagement. Even countries that favour nuclear expansion may fail to get the winning combination of factors needed for the project to go forward. Points of vulnerability and veto can emerge at various junctures throughout the lengthy process

required to get a plant from the early planning stages through to commercial operation. Windows of opportunity, when they present themselves, enable policy choices, however they are quite precarious and may not persist for very long. These windows of opportunity might be helped or hindered by facilitating conditions such as who has access to and influence over the decision-making process, relative energy security, and the level of political visibility nuclear power is exposed to during the period in question. Taken together, the window concept along with the facilitating conditions serve to orient the researcher for what they should be looking for when studying nuclear energy policy. Political structures (i.e. the decision-making process), the regulatory environment, market conditions, and support for nuclear power will vary case to case. This framework sets out a general idea for the conditions needed for a window of opportunity to present itself along with the factors that might serve to eventually close it. Having demonstrated the utility of this approach, there are elements that were not covered by this dissertation which may require further study.

One of the limitations of my approach was its focus on the decisions made at the state and provincial levels. Analysis at this level limited this dissertation's treatment of issues like social licence and public acceptance of nuclear power. The nuclear sector may continue to rely heavily on the state for assistance, however there is also a complex network of sub-state actors that play an important role in how the nuclear trajectory of a country takes shape. To better understand anti-nuclear sentiment, work would need to be done at the local level. This might include a study of social movements, civil society groups, and voter behaviour. A broader survey of participants from civil society might

also shed more light on why certain variables proved salient in some cases but not in others (i.e. what serves to amplify the political visibility of the technology?).

Potential Future Cases

One area for future research might include applying this analytical framework to cases that appear to be in transition like Japan and South Korea. Until recently, both were highly reliant on nuclear power, in part due to a lack of domestic sources of energy. Heavy reliance on fossil fuel imports led both countries to develop large nuclear fleets, along with the capacity to build and export reactors. Post-Fukushima, Japan has only restarted 5 reactors of 42 considered operable (WNN 2017a). In practice, this has meant that nuclear power which once accounted for approximately 30 percent of their supply mix, now provides less than 2 percent (Silverstein 2017). While the Japanese Government intends on maintaining nuclear power as a core part of the supply mix through to 2030, slow restarts and public opposition to the technology have made this policy increasingly untenable (The Japan Times 2017).[323] While an official phase out has not been declared, Japan may now be on the "glide path" towards a nuclear exit if no major political intervention is undertaken (Bradford 2013).

In the case of South Korea, following the election of President Moon Jae-in, the country now appears to be heading towards a phase out as well. Moon Jae-in is calling on South Korea to cancel its new build projects and planned refurbishments, and begin a staged phased out, allowing existing reactors licences to expire without the possibility of renewal (McCurry 2017). He has argued publicly that following the Fukushima accident,

[323] The 2014 Basic Energy Plan suggests that 20 to 22 percent of the country's electricity needs will be met using nuclear power (The Japan Times 2017). The energy plan is expected to be updated later this year.

the technology cannot be trusted as safe or environmentally friendly (ibid.). For a country that presently produces roughly one third of its electricity via nuclear power, this presents a significant policy change.

Japan and South Korea would present an opportunity for in-depth analysis of post-Fukushima responses in countries where domestic energy sources are limited and reliance on nuclear power has traditionally been high. While Japan has not formally committed to a phase out, both countries appear to be heading towards the same nuclear trajectory. Given the decades-long battle for a nuclear phase out in Germany, some time may be required to allow the dust to settle on these policy changes. Both may yet be subject to a reversal. That being said, these cases have the potential to greatly expand our understanding of the dynamics behind nuclear phase outs and the conditions that can serve to delay them.

Concluding Thoughts

When I first began considering the topic of nuclear power for my dissertation, I thought of the technology as a relatively straightforward means of helping to reduce emissions and address the complex issue of climate change. I saw it as a commercially available, mature technology that could potentially play a significant role in decarbonizing the world's electricity supply at a time when much of the world's energy supply was still driven by fossil fuels. I assumed (perhaps naively) that many of the technical barriers to entry would already be addressed in a state with decades of experience with the technology, allowing them to fully exploit the benefits of nuclear power in order to achieve their ambitious emissions reductions targets. Upon closer

inspection, a technological solution to climate change driven by nuclear power did not hold up to scrutiny.

In practice, there have only been a handful of OECD states looking to expand their nuclear fleets, with many only seeking to maintain existing capacity, and a growing chorus of them looking to phase out the technology altogether. This dissertation sought to better understand what led similarly situated states to adopt such divergent policy outcomes in the area of nuclear policy. It confirmed the literature's long held assertion that closed, technocratic decision-making processes, with limited public engagement, were factors positively correlated with nuclear expansion. However, the trend in energy governance is moving towards more inclusive, participatory models, that tend to be less favourable to commercial nuclear power. What does this mean for the future of nuclear power, and more broadly speaking, what does this tell us about the decision-making process surrounding energy policy?

One lesson to take away from all of this is that science and technology-related policies cannot be forced upon a society as the best and/or only option, relying primarily on technical justifications. These policies have social implications that need to be discussed and considered before public acceptance can be established. The lay person may not understand all of the technical features of a technology, nor are they necessarily going to be interested in being educated on its benefits, but that does not mean that policymakers have free rein to do as they please. While more research needs to be done to ascertain what counts as effective public consultation in the area of energy policy, its growing importance is difficult to dismiss.

A second, and related lesson, is that a slower process of development is not necessarily a negative outcome. Public trust and understanding has long been understood to be difficult to establish, and even more challenging to restore once lost (Slovic 1993). Rushing consultations to meet industry deadlines can make the approvals process longer and more arduous than it has to be. Long lead times and extensive consultation may be less than ideal from an economic standpoint, but are quickly becoming prerequisites of the regulatory process. There is no shortcut to gaining and maintaining public trust.

A third lesson is that simply because something is efficient and/or desirable from a technical point-of-view does not mean that it will be acceptable to the broader public. Opponents of nuclear power and other science and technology-driven policies cannot simply be dismissed as irrational, emotional, and/or ill-informed. Their mistrust of industry and the authorities responsible for regulating them is based on a lived experience, one in which they felt their best interests were not always maintained by those in power. For a democratic society, this means opening up the process, to allow those concerns to be raised, vetted, and included as part of an honest debate about the appropriateness of a given technology within society. The public benefits of nuclear power cannot be simply dictated to the public as part of an education campaign, but instead must be rigorously debated, and negotiated within a public forum.

For the nuclear industry, this move toward increased public engagement in energy policy may seem like an additional hurdle, one that makes their business that much more challenging. In practice, however, it should serve as a wake-up call to the need for a stronger public engagement strategy, one that goes beyond their nuclear communities, and speaks to a broader swath of society. Nuclear power has many merits, but it also

comes with a troubled history, marred by accidents, cost escalation, and delays. The nuclear renaissance may have fizzled in Western democratic states, but there remain ample opportunities for the existing fleet to play a role in off-setting emissions along with the potential for next generation reactors to be deployed in the coming decades. A rethink of how the nuclear industry and policymakers choose to address the public on these issues will be needed in order for sophisticated science and technology policy to be effectively advanced. The final frontier for nuclear energy will not be addressed in a lab, instead, it will take place in a different milieu. It is a complex social issue, one that will require patience, dialogue, and understanding if it is to be effectively overcome.

Appendix 1: Stakeholders Interviewed[324]

Name	Position and Organization[325]	Date of Interview	In-Person/Telephone/ Skype/E-mail
Ailine Trometer	Doctoral Student	September 17, 2014	Skype
Alastair McIvor	Director of Corporate Operations, AECL	September 17, 2014	Phone
Andrew Prudil	Doctoral Student, Royal Military College	October 23, 2014	Skype
Brennain Lloyd	Project Coordinator, Northwatch	May 13, 2015	Phone
Carl Bourassa		August 27, 2014	In-Person (Vancouver, BC)
Christine Wörlen	CEO/Founder, Arepo Consult	November 20, 2014	Phone
Filip Tuomisto	Professor of Nuclear Engineering, Aalto University and Board Member of the Finnish Nuclear Society	March 25, 2015	Phone
Francois Rinfret	Director, Darlington Regulatory Program, CNSC	October 24, 2014	Phone
George Smitherman	Former Ontario Minister of Energy and Infrastructure, Ontario Liberal Party	June 12, 2015	Phone
Hanna Halmeenpää	VP of Pro Hanhikivi and Green League MP	May 6, 2015	Skype
Jacques Plourde		November 24, 2014	Skype
James Scongack	VP Corporate Affairs & Environment, Bruce Power	October 31, 2014	Phone
Jean LeClair	Director, Uranium Mines and Mills Division, CNSC	March 12, 2015	Phone
Jeremy Whitlock	Manager, Non-Proliferation & Safeguards, AECL	September 19, 2014	In-Person (Calgary, AB)
John Barrett		October 10, 2014	Phone

[324] There were 11 anonymous interviews conducted for this dissertation that were not included in this list.

[325] This table lists the organization and position that each participant was affiliated with at the time of the interview. For some individuals, it refers to a relevant position that they held in the past. In these cases, the position is noted as former. It is blank in cases where consent was not given to list their organization.

John Bennett	Executive Director, Sierra Club Canada	March 5, 2015	Phone
John Hayes		October 22, 2014	Phone
John Stewart	Director of Policy, CNA	October 3, 2014	Phone
Jorma Aurela	Chief Engineer, MEE	March 26, 2015	Phone
Joy Shikaze	Executive Director, Women in Nuclear Canada	October 29, 2014	Phone
Justin Hannah	Senior Manager, Marketing & External Relations, Candu Energy	October 30, 2014	Phone
Kerstin Ramdohr		October 21, 2014	Phone
Klaus Loew	Department of Public Relations, Federal Office for Radiation Protection	July 7, 2015	E-mail
Marcel de Vos	Nuclear Regulation Professional	November 12, 2014 and November 19, 2014	E-mail and Phone
Michael Sailer	CEO, Öko-Institut, and Chairman of the Nuclear Waste Management Commission, and Member of the RSK, and Former Member of the Ethics Commission for a Safe Energy Supply	May 12, 2015	Phone
Minna Tuomainen	Project Manager for Olkiluoto 3 within the Department of Nuclear Reactor Regulation, STUK	February 20, 2015	Phone

Miranda Schreurs	Director of Environmental Policy Research Centre, and Professor of Comparative Politics at the Freie Universität Berlin, and Former Member of the Ethics Commission for a Safe Energy Supply	March 26, 2015	Phone
Neil Alexander	Executive Director, Sylvia Fedoruk Centre	October 3, 2014	Phone
Pasi Tuohimaa	Head of Communications and Corporate Relations, TVO	October 7, 2014	Phone
Pierre Tremblay	President of Canadian Nuclear Partners and Former Chief Operating Officer at OPG	November 12, 2014	Phone
Robert Walker	President and CEO, CNL	March 11, 2015	Phone
Roman Rjabchikov		December 4, 2014	Skype
Sahil Gupta	Analyst, AMEC NSS	September 10, 2014	Phone
Satu Hassi	Former Minister of the Environment and Development and Current Green League MP	June 10, 2015	Phone
Sunni Locatelli	Director General, Strategic Communications Directorate, CNSC	January 7, 2015	E-mail
Tuomo Huttunen	Stakeholder Manager, Fennovoima	March 10, 2015	Phone
Ulrich Waas		April 20, 2015	Phone

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