

Risk to Reward: How Discourses of Risk Shape Nuclear Energy and Public Perception

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Abstract

This dissertation examines how nuclear energy has come to occupy different discursive positions, shifting from a technology associated with catastrophic risk to one increasingly framed as a necessary reward in the context of decarbonization. It asks: beyond changing material conditions, what enduring discourses make it possible for nuclear power to be understood both as an unacceptable hazard and as an energy solution? This project investigates how discourses of risk shape public understandings of nuclear energy across time. This dissertation adopts an interdisciplinary framework grounded in science and technology studies (STS), energy humanities, risk theory, and the history of science and technology. It approaches discourse in a Foucauldian sense, treating nuclear energy as an object constituted through language, symbolism, institutional communications, and cultural interpretations. Methodologically, this project combines historical analysis, discourse analysis, and semi-structured interviews in order to link 5 chapters which trace the historical emergence of nuclear risk discourse, the development of civilian nuclear power, the principal domains through which nuclear risk is articulated, and contemporary nuclear risk communication in Canada. The final two chapters turn to modern Canadian case studies: Ontario Power Generation's "Recast Nuclear" campaign and the politics of siting a Deep Geological Repository in South Bruce, Ontario. Overall, this dissertation argues that nuclear risk is not fixed, but socially and culturally produced. Nuclear energy's meanings endure and evolve through discourse, shaping how it is feared, legitimized, and politically mobilized in the present.

Dedication

To Aunt Joan, the smartest person I've ever known, who sat with me for hours on end, giving me mental respite during many challenging moments.

And to my parents, who raised me to be insatiably curious.

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Introduction

In the aftermath of the Fukushima Daiichi disaster in Japan, Germany moved to phase out nuclear power. Following the magnitude 9.0 Earthquake and the tsunami that overwhelmed Fukushima Daiichi nuclear power plant, three reactor cores melted down, reinforcing nuclear energy's association with catastrophic risk in the public and political imagination. In Germany, the decision to abandon nuclear power reflected more than an immediate policy response; it signalled a broader judgment that the technology, hampered by the legacies of Three Mile Island, Chernobyl, and Fukushima, represented an unacceptable hazard. At the time, the phase-out was framed as pragmatic, and a declaration that nuclear energy was simply not worth the risk. Yet by 2026, something unexpected happened. German Chancellor Friedrich Merz described his nation's retreat from nuclear energy as a "serious strategic mistake," and European Commission President Ursula von der Leyen echoed these sentiments and lamented the overall reduction of nuclear capacity across Europe. What, then, accounts for this reversal? The conventional way to answer this question is to attend to the environmental, political and economic situation in Germany and form an answer based on a combination of the need for energy security, the issues with foreign fossil fuel consumption, and the global decarbonization mandate. This project rather seeks to understand how we reached a point wherein nuclear energy can occupy such diametric discourses. Throughout this dissertation I answer the question, beyond changing material conditions, what enduring discourses make it possible for nuclear power to both be posited as an unnecessary risk *and* an unmissable reward?

My interest in this topic emerged from the context in which I grew up. In my home province of Ontario, nuclear energy occupies a favourable position within energy policy, and, to an extent, public opinion. The juxtaposition then is that I grew up in a social and political environment that was broadly supportive of nuclear power, while at the same time being told the well known historical narratives of catastrophe and fear that often qualify oppositions to nuclear energy. This tension became the point of departure for my project. Throughout the dissertation, I examine how discourses of risk shape public perceptions of nuclear energy. My analysis arrives at a conclusion through three arteries of discovery: 1. Through analyzing the discourses of risk which emerge from nuclear energy histories, 2. Through utilizing risk scholarship to demonstrate how discourses of risk produce risk perceptions of nuclear energy, and 3. Using my own research to argue that risk discourses evolve temporally and contextually, reflecting the risk to reward scale laid out in my title. This project is not meant to exist within a specific canon, rather operate as an interdisciplinary study, as reflected in my theoretical framework. This is also not a critical evaluation of nuclear energy, or a focus on how nuclear fear arose via the militarization of the atom and the impact of atomic weapons. Rather I critically evaluate how the discourses of risk surrounding nuclear energy are partially born out of connection between the military and civilian applications of nuclear fission, and how they exist in a civilian capacity today.

Research Objectives

This project was motivated by a desire to conduct contemporary and organic research that reflects the present state of nuclear energy risk discourse, while remaining attentive to the specific political and cultural conditions which shape nuclear energy in Ontario and Canada. The

nuclear energy histories laid in the first two chapters are not Canada-specific, but western focused. I wanted this project to speak to the current moment, particularly as nuclear energy is being rehabilitated in the context of decarbonization and energy security, but to do so without losing sight of the historical events that continue to structure public understandings of nuclear risk. For that reason, the project often proceeds by presenting risk inducing case studies before unpacking their theoretical underpinnings, allowing those moments to retain their historical and cultural weight. I was also motivated by a preference for breadth over depth, and by an interest in tracing nuclear risk discourse longitudinally across multiple periods and contexts in order to identify both continuity and change over time. Finally, the project is driven by an interdisciplinary research motivation, bringing together insights from STS, risk theory, energy humanities, history of science and technology, and environmental communications scholarship in order to produce an account of how nuclear energy risk is communicated and contested across disciplines.

Theoretical Framework

Before turning to the specific theoretical frameworks used throughout this dissertation, it is important to clarify how discourse is understood in this analysis. This project adopts a Foucauldian conception of discourse, wherein discourse is concerned with the “relations between statements” (Foucault, 1972, p. 31). In this sense, discourse is more than language alone; it includes statements, institutional practices, symbols, and communications that help constitute the objects of which they speak. These elements produce a corpus of knowledge that constructs the object itself (p. 33), which in this case is nuclear energy. This dissertation treats not only written

and spoken language as discourse, but also the symbolism, iconography, and broader cultural touchpoints through which nuclear energy acquires meaning. The institutions and social/cultural processes that produce these discourses cannot be reduced to any single expression or site. Rather, they operate within a broader web of discursive formations that shape how nuclear energy and nuclear risk are understood (p. 45). Discourse is taken from important historical events, negotiations of nuclear energy risk, and scholarly and cultural analysis. This project operates on an interdisciplinary plane, and pulls from several areas of study including science and technology studies (STS), energy humanities, risk theory, history of science and technology, philosophy, and policy/sociology/cultural studies.

This project is situated within scholarship in science and technology studies (STS) and the philosophy of science and technology, drawing on work that examines how technologies shape, and are shaped by, social life. It is informed first by scholarship on the structure and institutionalization of science (Russell, 1931; Merton, 1938; Kuhn, 1996), which provides an important foundation for understanding how scientific authority, knowledge production, and cultural paradigms inform scientific and technological development. From there, this project engages foundational philosophical critiques of technology's role in modern society, particularly in relation to technological authority, and the politics of technological systems (Ellul, 1964; Heidegger, 1977; Winner, 1977). It is also informed by social constructivist approaches that emphasize the cultural contingency of technological development and the social processes through which technologies acquire meaning (Pinch & Bijker, 1984; Bloor, 1991). These perspectives are complemented by more recent STS scholarship on energy and sociotechnical imaginaries (Jasanoff & Kim, 2015), as well as work that specifically examines the relationship

between nuclear energy and society, including questions of public knowledge, authority and risk (Winner, 1989; Wynne, 1989). This project also engages contemporary scholarship on the politics of nuclear waste management (Bell, 2023; Hietala, 2021; van Wyck, 2005). STS then provides the conceptual basis for analyzing nuclear energy not as a neutral object, but as a socially embedded and politically contested technology.

Energy humanities, while emerging largely through critiques of petrocultures and the saturation of fossil fuels within modern life (Szeman & Boyer, 2017), offers important insights into the relationship between nuclear energy and culture. This project draws on energy humanities as a critical site for analyzing nuclear discourse, particularly in the aftermath of nuclear accidents and meltdowns. It engages scholarship on the cultural impacts and harms of nuclear energy (Masco, 2013), work on nuclear energy communication and discourse (Farrell & Goodnight, 1981; Kinsella, 2005; Chen, 2023), and analyses of nuclear representation in popular culture (Perrine, 1998; Matthews, 2012). It also draws on texts that interpret major nuclear events through an energy humanities lens, such as Fukushima as a cultural and political rupture point (Elliott, 2013). Energy Humanities helps frame nuclear energy not only as a material and technical system, but as a cultural object whose meanings are produced through cultural discourses.

This project is anchored in a Beckian conception of risk society, which argues that late modernity is increasingly defined by the production, distribution and management of human generated risks (Beck, 1992, 2009). I am particularly concerned with how the push for high technological modernity intensified environmental and ecological forms of risk, and with the

cultural and political frameworks through which such risks are interpreted (Beck, 1995; Douglas & Wildavsky, 1982). The project also draws on key risk scholarship concerning the social amplification of risk, especially the ways institutions and media magnify or soften risk perceptions (Kasperson et al., 1988; Kasperson & Kasperson, 1989), as well as foundational work on the social dimensions of public responses to danger (Slovic, 1987). It further engages scholarship that treats risk as a constitutive feature of modern technological systems, particularly complex systems prone to accident, and organizational breakdown (Perrow, 1984; Vaughan, 1996). These perspectives are complemented by scholarship that examines nuclear energy specifically through the lens of risk, including work on nuclear politics, and the enduring stigma attached to nuclear technologies and the spaces they impact (Byrne & Hoffman, 1996; Flynn et al., 2003; Miyazawa, 2022). This literature provides the basis for understanding nuclear energy risk as a socially and culturally produced phenomenon.

In the history of science and technology, this project draws on key texts that trace the discovery and development of nuclear energy (Cathcart, 2004; Kevles, 1997; Lavine, 2013; Campos, 2015), as well as foundational histories of the Manhattan Project and the atomic age (Rhodes, 1986; Bird & Sherwin, 2005). It also engages scholarship on nuclear culture, including the rise of nuclear fear, the political development of the “peaceful atom,” and the aftermath of nuclear accidents (Boyer, 1985; Wills, 2006; Weart, 2012; Hamblin, 2021; Plokhy, 2018). These historical perspectives are complemented by case studies of national nuclear cultures and politics, particularly in France and the United States (Hecht, 2009; Zaretsky, 2018). Beyond nuclear-specific histories, the project also considers the broader environmental discourses within

which anti-nuclear sentiment emerged and developed (Dunaway, 2015). This historical framework informs the project as a whole, and carries through the chapters that follow.

Chapter Layout

Before outlining the chapters, it is important to clarify the methodological approach that connects these different sites of analysis. This dissertation employs an interdisciplinary qualitative methodology that combines historical analysis, discourse analysis, and semi-structured interviews (chapter 5). Across the early chapters, I analyze historical events, scholarly texts, political rhetoric, media narratives, and cultural productions in order to trace how discourses of nuclear risk emerge and evolve over time. In the later chapters, this approach shifts toward contemporary empirical cases, including a discourse analysis of a nuclear campaign, as well as semi-structured interviews and analysis related to the proposed Deep Geological Repository (DGR) in South Bruce for housing Canada's nuclear waste. While the materials and scale of analysis vary by chapter, each chapter is guided by a shared concern with how nuclear energy risk is made meaningful through language, symbolism, and institutional communications. The materials which reoccur throughout this project are advertisements, public communications, media narratives and policy documents.

This dissertation is organized into five chapters, each of which can be read as an independent study, though all are linked by a sustained focus on nuclear energy discourses of risk. Chapters 1 and 2 share a similar structure, pairing historical analysis with cultural, communicative, and philosophical/STS perspectives on nuclear power in the periods under examination. Chapter 1 focuses on the early history of nuclear energy, from the discovery of radiation to the construction and detonation of the atomic bomb. Although the period from 1896

to 1945 is often undertheorized in STS and energy humanities scholarship, it contains many key events, and the discourses that produced the foundational discursive binary of promise and peril that continue to define nuclear energy. The chapter is anchored by major scientific discoveries and institutional breakthroughs such as x-rays and radium, the scientific advances leading to nuclear fission, and the Manhattan Project. Throughout this chapter, I examine how risk became central to the cultural experience of atomic power, through both its material consequences and its strong symbolism.

Chapter 2 mirrors Chapter 1 in structure and tone, but shifts focus to nuclear energy developments from 1945 to the present. It examines the relationship between the military and civilian uses of nuclear technology, while also tracing the development of civilian nuclear power. This chapter addresses key moments including the atoms for peace movement, the anti-nuclear and later environmental resistance to nuclear energy, the expansion of civilian nuclear development following the 1973 OPEC oil crisis, and the major nuclear accidents that continue to shape nuclear energy politics today. Chapter 2 is critical because it presents the troubled and often contradictory emergence of civilian nuclear power, while also situating that history alongside the contemporary moment, in which many nations are again pursuing nuclear expansion. In chapter 2, the throughline remains risk, but my analysis continually shifts due to the changing conditions throughout the 21st century in which climate change, decarbonization, and energy security have reframed nuclear energy as a potential energy solution. Overall this chapter argues that the promise/peril discursive binary is not an output, but a feature of nuclear energy, a co-constitutive production due to both material and cultural contexts.

Chapter 3 builds on the historical and theoretical insights developed in Chapters 1 and 2 by identifying three primary areas through which discourses of risk attach to nuclear energy: environment, health, and political economy. With respect to the environment, this chapter examines the radiological impacts of nuclear weapons and nuclear meltdowns on ecosystems and the natural world. Risk perceptions in this domain are shaped by a manufactured versus natural binary, rooted in the enduring cultural distinction between nature and culture. The “manufactured” side of this binary reflects a persistent theme in nuclear history and theory: that splitting the atom, and the broader pursuit of technological modernity, represents a profound disruption of the natural order. In relation to health, this chapter uses the Goiânia accident and the radioactive chapati experiment as case studies to show how perceptions of radiological danger are structured by invisibility and toxicity. Radiation’s imperceptibility makes risk difficult to apprehend, requiring publics to place trust in experts and institutions whose authority has often been undermined by failures in the management of radiological harm. These perceptions are intensified by the idea of toxicity, which reflects a broader cultural anxiety that the by-products of industrialization and scientific progress are contaminating and causing intimate personal harm. Finally, the chapter examines political-economic risk by considering how nuclear accidents and failed construction projects expose tensions in regulatory governance, the failures produced by prevailing economic incentive structures, and the broader economic and political vulnerabilities associated with nuclear development.

Chapter 4 is the first of two chapters drawing on my original research, and marks a shift in this project toward contemporary case studies of how pro-nuclear actors negotiate and communicate risk. It focuses on Ontario Power Generation’s recent “Recast Nuclear” advertising

campaign, which attempts to reposition nuclear energy through discourses of quantification that frame it as the pragmatic energy source for the present and future. While the campaign appears on the surface as a response to recent film and television portrayals that cast nuclear energy in an unfavorable light, through discourse analysis, I uncover other motivations. I argue that the campaign uses quantification, numeracy, and fact-based statistical claims to construct rhetorical categories of “good” and “bad” energy sources, associating nuclear energy with efficiency, cleanliness, and potency, while positioning competing sources as dirty, emitting, or inefficient. In doing so, the campaign does more than defend nuclear energy’s image; it works to naturalize the “nuclear advantage” through the authority of numbers. Overall, this chapter examines the cultural production and political significance of these discourses of quantification, while arguing that the timing of the campaign is closely aligned with broader provincial and federal policy efforts to expand nuclear power.

Chapter 5 examines the contemporary case of Canada’s planned Deep Geological Repository (DGR) for the long-term storage of used nuclear fuel. This chapter draws on research conducted in South Bruce, Ontario, in the months leading up to the referendum that ultimately determined whether the community would serve as the host site. My research focused on the negotiations between local residents and the Nuclear Waste Management Organization (NWMO), the federally mandated body responsible for identifying a willing host community. I argue that the underlying tensions in South Bruce about whether to host the DGR are best understood as a conflict between competing sociotechnical imaginaries (Jasanoff & Kim, 2015). On one side are technocrats who frame the area as an ideal site for the DGR, emphasizing both its development potential within an agrarian economy and its familiarity with nuclear energy due

to its proximity to Bruce Power. On the other side are farmers and local residents who imagine South Bruce's future as agrarian and centered on dairy farming and the local creamery. These conclusions are based on interviews with three community members and project stakeholders, as well as a discourse analysis of NWMO literature.

Positionality and Future Motivations

This project is written from a broadly pro-nuclear perspective. At the outset, it was intended to lean more clearly in a pro-nuclear direction in both argument and tone. However, after engaging with relevant literature, particularly in STS and the energy humanities, it became clear that much of the existing scholarship approaches nuclear energy from an anti-nuclear position, often emphasizing catastrophe, environmental harm, secrecy, authoritarianism, and institutional failure. Those critiques are important and, in many cases, key to understanding the cultural and political history of nuclear energy. As I worked through the histories of the atomic bomb, nuclear accidents, and anti-nuclear activism, it clarified the need to take this scholarship seriously. At the same time, the project also seeks to make space for less risk-saturated accounts of contemporary nuclear energy, particularly in terms of its communicative strategies, policy momentum, and the renewed role of nuclear energy in debates over decarbonization. The anti-nuclear environmentalist isn't as fitting in a 21st century analysis, and the race to build more nuclear energy can't be reduced to an erroneous risk calculation. The early chapters lean more heavily into negative risk associations with nuclear power, however I try to balance this scale in the later chapters.

This balance also reflects the practical orientation of the dissertation. Because this project is meant to support my future work as a practitioner in nuclear communications and policy, it places particular attention on how industry actors communicate and manage nuclear meaning in the present. For that reason, while the dissertation is theoretically grounded, it is equally concerned with applied questions of discourse and public communications. This project then operates not only as an academic intervention, but as a broader research program that uses important historical and theoretical foundations to uncover the contemporary communicative conditions in which nuclear energy is both a risk and reward. My orientation between theory and practice shows that discourse is more than an abstract object of interpretation, it is an active field of meaning-making with consequences for energy policy and technological acceptance. While this dissertation remains critical, it is written with an awareness of the communicative challenges of the nuclear sector, and is shaped in part by my interest in contributing to that sector as a future practitioner.

Chapter 1

Nuclear Energy, 1896-1945

Introduction

This chapter charts the scientific, cultural, and philosophical evolution of nuclear energy between 1896 and 1945, an evolution that culminates in the detonation of the atomic bomb in Hiroshima and Nagasaki in 1945. While many histories of nuclear energy begin with the Manhattan Project, this chapter contends that the discursive foundations of nuclear power, and its enduring binary of promise and peril, were established in the early 20th century. This chapter is broken into two sections, with identical subsections. The first section, *The Source*, traces the early scientific breakthroughs that made nuclear energy possible, beginning with the discovery of X-rays and radioactivity, and progressing through the identification of the nucleus, atomic structure, and nuclear fission. These discoveries not only revolutionized physics but also shaped public imaginaries around the potential of atomic energy. Following a brief history of this era, I offer the communicative and cultural dimensions that investigate the popular discourses attached to key discoveries of early nuclear energy, including the introduction of radio mania and radiophobia. I conclude this section with popular philosophies of science and technology which dealt with the popularization of atomic science as an epistemology.

The second section, *The Manhattan Project and the Atomic Bomb*, examines the scientific mobilization during World War II and the production of nuclear weapons, culminating in the Trinity Test and the bombings of Hiroshima and Nagasaki. This historical overview is followed by an analysis of popular post-bomb discourses, examining how the atom and the atomic bomb came to be understood not merely as scientific phenomena, but as mythic, autonomous forces, shaped in large part by the visual power of the mushroom cloud. After a

brief consideration of Cold War risk communication, I turn to philosophical and STS (Science and Technology Studies) responses to the emergence of science and technology as institutional forces, and to the moral questions that arise when scientific knowledge is weaponized at scale. In doing so, I analyse philosophies of science that seek to make sense of atomic energy and the expansion of science as a cultural institution; one that reshapes the fabric of social life and propels societies into modernity.

This chapter is not a complete history of nuclear energy, nor does it delve into certain aspects of war and destruction. This chapter selects specific histories, discourses, case studies and philosophies which inform the overall argument and research of this dissertation. The key currents throughout this chapter are, 1. The dueling discourses of promise and peril which continue to constitute nuclear energy politics, or as Farrell & Goodnight (1981) conceptualize “a realized future and a future without reality” (p.278), 2. The development of nuclear science, and the proponents of nuclear energy as politically charged, 3. The development of nuclear fear and the associations between nuclear energy and risk (Weart, 2012). This chapter, along with the rest of the project focuses on the communication and culture of nuclear energy from a western point of view.

Part 1: The source

Histories of nuclear energy often begin with the Manhattan Project, the key site where the development of the atomic bomb occurred. The earlier period from 1895 (the discovery of X-rays) until the late 1930s is equally critical, as these scientific discoveries not only paved the way for nuclear energy production, but nuclear energy discourses. It was during these decades that the political stakes and risk imaginaries of nuclear energy were established, as the rise of nuclear physics fundamentally transformed understandings of the physical world and revealed

the unprecedented power unlocked through the manipulation of subatomic particles. Until the late nineteenth century, even the existence of the atom remained contested among scientists (Rhodes, 1986, p. 31), yet what followed were rapid developments which altered the course of humanity and our relationship with risk vis a vis the atom, and its capacity for both power, and destruction. Together, these early scientific breakthroughs laid the epistemic and cultural foundations upon which nuclear energy would later be politicized, feared, and governed as a uniquely modern risk.

Radiation

In 1895, Wilhelm Conrad Roentgen, a German physicist, observed an unexpected fluorescent glow emanating from a glass tube, leading him to identify a new type of ray that he termed "X-rays", the "X" denoting an unknown variable (Lavine, 2013, p. 11). Roentgen subsequently demonstrated that these rays could penetrate soft human tissue while being obstructed by denser materials like bone, an observation that would have profound implications for both physics and medicine. The discovery of X-rays, later recognized with the first Nobel Prize in Physics in 1901¹, marked a catalyzing moment in the emerging field of nuclear physics. X-rays became somewhat of an instant phenomena, with many hospital surgical departments having machines within a year of Roentgen's discovery (Kevles, 1997). Roentgen's X-Ray was quickly followed up by French Physicist Henri Becquerel, who first observed a source of natural radiation (radiation without the aid of rays or light), by way of inert uranium salt. This salt piqued Becquerel's interest as the uranium seemed to give off a fluorescence similar to an x-ray.

¹ Along with Roentgen, Becquerel and the Currie's were awarded the Nobel Prize in physics in 1903, J.J. Thompson in 1906, Earnest Rutherford in 1908 (for chemistry however), Einstein in 1921, Bohr in 1922, Fermi in 1938, Rabi in 1944, Cockroft and Walton in 1951, and many others who worked on nuclear physics, x-rays, and radiation. These nobel prizes, often for cornerstone discoveries, reflect the rapid development of nuclear physics in the early 20th century.

Working with Becquerel in the late 19th century, Curie coined the term *radioactivity* while observing uranium compounds, and determining that the emission of rays from uranium was a result of its actual atomic properties, not interactions between molecules (American Physical Society, 2024). Following this, the discovery of many naturally radioactive elements followed suit, such as thorium, radium and polonium. Marie and her husband Pierre continued to make key discoveries in the space of nuclear physics, until their deaths at a young age, Marie from exposure to radiation.

Nuclear Physics

The basis of nuclear physics and the most consequential breakthrough in the development of nuclear energy was the discovery of the atomic nucleus by physicist Ernest Rutherford², often referred to as the “father of nuclear physics.” Rutherford, a New Zealander, first proposed a theory of atomic structure in 1911, spurred by the success of his gold foil experiment. In the experiment, Rutherford, along with German physicist Hans Geiger and undergraduate student Ernest Marsden, shot positively charged alpha particles at a piece of gold foil.³ Most of the particles passed through, however some had their path altered, and some bounced back. The only plausible explanation was the existence of a dense, positively charged core within the atom; the nucleus. As Rutherford memorably put it, the observation was “as surprising as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you” (Rhodes, 1986, p. 49).

While Rutherford stopped short of actually splitting a nucleus, he proposed the idea that if one could accelerate a particle with enough speed, it is possible that an atom could split. This was the

² Earning the nickname, “the father of nuclear physics,” is not earned lightly. Rutherford was such an ardent nuclear physicist, he did not believe any other branch of science other than physics is equitable to, “stamp collecting,” and directed his researchers to only focus on the nucleus (Cathcart, 2004, p.15). This is all despite the irony of winning a Nobel Prize in Chemistry in 1908 for his work on radiation.

³ Alpha particles had been discovered as a byproduct of radiation by Becquerel in 1896.

theoretical basis to build more powerful particle accelerators, and further experiment with the new atomic structure. Rutherford would go on to contribute much more to nuclear physics over his career, such as hypothesizing the idea of elemental transmutation, more commonly known as radioactive decay.

In 1932, John Cockcroft and Ernest Walton achieved the first successful splitting of the atom at Cambridge University's Cavendish Laboratory by bombarding lithium nuclei with high-energy protons, producing two helium atoms. This not only was a feat itself, but also confirmed Einstein's mass-energy equivalence ($E=mc^2$), as the kinetic energy of the new nuclei measured more than the original (Cathcart, 2004). Simply put, the reaction showed that mass can be converted into energy, with a small decrease in mass released as energy during the nuclear reaction. Weeks later, one of the most consequential discoveries in nuclear science was met with little public attention (Williams, 2011). James Chadwick, a scientist working in the same lab, discovered the neutron. The neutron, is a large uncharged particle, was the ammunition needed to probe nuclei to trigger nuclear fission, later unveiled in 1938. Without the neutron, nuclear fission, chain reactions, and the eventual military application of nuclear energy would not have been possible; its discovery was essential to the development of nuclear physics (Nesvizhevsky & Villain, 2017).

Although Cockcroft and Walton showed that atoms could be split, doing so required enormous amounts of energy. The efficiency of modern nuclear reactors, by contrast, lies in exploiting the properties of heavy nuclei. This was confirmed in 1938 in Germany at the Kaiser Wilhelm Institute for Chemistry. The theory of the strong force is that there is a force in the

nucleus which binds the positively charged protons and neutral neutrons. The larger the nucleus, the weaker the strong force is, the easier it is to split. Uranium is the heaviest naturally occurring element and naturally radioactive, so when Lise Meitner, Otto Hahn and Fritz Straßmann split a Uranium atom, the amount of energy emitted was colossal. This is ideal for generating nuclear energy, also known as nuclear fission. More than just energy, the scientists observed that the reaction emitted neutrons, which theoretically could smash into other particles, releasing more energy (U.S. Department of Energy, Office of History and Heritage Resources, n.d.). This is the theoretical basis for a chain reaction, and is explored in the next section, however, the Germans discovering fission first soon signalled to allied scientists that the Nazi's were closing in on a potential devastating weapon (Bernstein, 2001).

Communication and Cultural Dimensions: Early Nuclear Energy

Introduction

The discovery of X-rays in 1895 and the subsequent isolation of radium in the early 20th century catalyzed not only scientific breakthroughs but also widespread cultural fascination and anxiety. This section examines how these two phenomena laid the discursive and symbolic groundwork for modern understandings of nuclear energy. Through the dual lenses of “radio mania” and “radiophobia”, the public response to X-rays and radium reveals an early articulation of the promise–peril binary that continues to shape nuclear energy discourse today. By exploring the cultural, medical, and commercial applications, as well as the growing awareness of their risks, this section contextualizes how early nuclear science became embedded in both utopian imaginaries and growing anxieties. While the public was largely captivated by the spectacle of X-rays and radium, cultural awareness of nuclear energy remained limited in the early 20th

century. This section also explores how early portrayals of atomic power, particularly in literature and popular media, reflected both hopeful speculation and emerging fears about science's expanding role in military and social applications.

X-rays and Radium

The discovery and rapid adoption of X-rays in the early 20th century laid the foundation for a discursive binary that, even now, continues to shape narratives around nuclear energy. This binary has been framed in various ways; excitement and fear, promise and peril, but during this era, it materialized as "radiomania" and "radiophobia" (Lavine, 2013). Given their material properties, it is easy to understand why X-rays caused such a cultural stir: they rendered the invisible visible. What is taken for granted today was profoundly disruptive at the time, as objects once understood to be solid could suddenly be seen through (Sullivan, 2011). This phenomenon was first captured in Röntgen's now-iconic image of a skeletal hand with a wedding ring.



Figure 1.1. *X-ray by Wilhelm Röntgen of Albert von Kölliker's hand (1896).* Source: Röntgen (1896). Public domain via Wikimedia Commons.

Radiomania

X-rays triggered a medical revolution, and for the first time allowed doctors to see inside their patients to detect broken bones and tumours, fundamentally changing the diagnostic and surgical process. The cultural fascination around these machines first and foremost grew out of the medical impact and scientific capital that X rays carried (Lavine, 2013, p.69). The discovery of X-rays, according to Kevles (1997), had serious epistemological impacts, as it was now understood that humanity could now “see the unseen.” This went beyond medical boundaries, as hobbyists could buy at home X-ray machines or see one at a traveling circus, even receive x-rays at shoe stores, where “shoe fitting fluoroscopes” were advertised and used to ensure the perfect fit (Meier, 2018). This materialized in “radiomania,” a widespread fascination with the new applicability of x-ray science. Radio-mania extended to radium, a naturally occurring radioactive

element which caught the imagination of general society. The initial reason for the cultural obsession with radium is because it proved effective as a medical tool. Medical professionals found that the application of radium salt for dermatological uses such as exposed tumours or birthmarks were effective, and radium therapy could be used to ease discomfort in patients with pain intensive maladies (Genet, 1998). Much like many initial medical applications, radium took off as a commercially viable product, using scientific capital to liken radium with discourses of health and wellness (Campos, 2015; Lavine, 2013). All kinds of products, both containing and claiming to contain radium exploded on the shelves, from radium condoms, to radium shampoo. Radium. In Sweden for example, the cultural shift toward embracing radium as a health product meant citizens could enjoy one of Sweden's radioactive spas for a much needed health boost (Eriksson & O'Hagan, 2021). This idea was replicated as seen in figure 1.2., when the Radium Sulphur Springs opened in L.A. in 1908. After an unsuccessful attempt to drill for oil revealed a natural spring, founder G.P. Gehrig opened the spa, and marketed it through claiming the water was “germicide” and “radioactive” (Morrison, 2021). The spa was successful, closing in 1929 after impacts from the great depression no longer made it a viable operation.



Figure 1.2. *Radium Sulphur Springs on Melrose Ave in Los Angeles, U.S.A.* Source: Neuner Co. (1912). Public Domain via Wikimedia Commons.

Radium became a powerful fad, generating widespread excitement over the potential of radioactivity. The magic of something able to glow by its very properties applied to a myriad of hopeful products. Glowing radioactive cocktails, carrying a spinthariscopes (a small tube with a glass peep hole where you could observe naturally decaying radium) in one's pocket, using radium to detect fake diamonds, it seemed there was no limit to where radium applied (Badash, 1979). The combination of its early medical effectiveness, the emergence of science as a cultural institution (explored in the next section), its physical properties combined to exhibit what Campos (2015) calls “life-giving” qualities (p.37). This is salient because it works to imbue properties of atomic science with life affirming qualities, which often is reflected in the discourses of the period. One example is when physicist John Burke introduced radium salts into beef broth and witnessed bacteria like formations under his microscope. This discovery was refuted later by biologists, not before newspapers framed the experiment as radium being the “secret to life” (Hamilton, 2016). Radiomania then is a cultural phenomenon rooted in the

symbolic power of atomic science. It is the basis of well known utopian discourses of nuclear energy that emerged in the 1950s. It is also the foundation of one half of the promise-peril binary which qualifies much of the discussion of nuclear energy to this day.

Radiophobia

As the intensity of radio mania began to quell, a few key instances led to a steady rise of radiophobia. As doctors applied X-rays to patients, reports emerged describing skin burns as a common outcome of treatment. An 1897 article in the NY Times begins, “After the courts have awarded heavy money damages in a few cases of injury and disfigurement by the x ray, the manipulators of that mysterious energy will probably employ the precautions which experience has already shown to be necessary” (*Injury from the X-rays*, 1897). The early, unregulated days of X-ray exposure left many individuals with skin burns, blisters, hair loss, amputations, and in some cases death (Sansare et al., 2011). These cases represent some of the earliest documented harms of ionizing radiation, revealing the significant and often devastating effects of early X-ray exposure. While early radiotherapy showed promise in treating ailments like lupus and nail fungus, its unregulated use often resulted in serious health consequences, including dermatitis, leukemia, and thyroid malignancies (Vardeu et al., 2020). Beyond the medical misuse, the cultural fascination and commercialization of radium also had serious health consequences.

In the 1910’s and 20’s, one product called Radithor, a solution of radium suspended in water, was marketed for a range of afflictions, from fatigue to sexual dysfunction (Clark, 1997). This product proved to be dangerous, as in 1932, Eben Byers, a wealthy American industrialist, drank so much Radithor that he poisoned himself and died (Mullner, 1999). These cases eventually prompted a surge of regulations around X rays and radium, but the overall cultural

momentum behind these scientific phenomena reflects the fascination with nuclear energy, the paradigmatic discursive risk pattern of promise and peril that follows nuclear energy, and the techno-optimism and utopianism that often frames discussions around nuclear energy potential. The most famous story of the perils of radium occurred in wartime factories in the 1920's and 30's where 30 of the “radium” girls died due to radiation poisoning from radium paint used to add lume to watch dials. This is a core event in the evolution of nuclear energy's risk relationship with health, an idea I explore through the concept of toxicity discourse in Chapter 3.



Figure 1.3. *Workers at the U.S. Radium Corporation, circa 1922–1923. Known as the “Radium Girls.”* Source: U.S. Department of Energy via Wikimedia Commons (Public domain).

By the 1930's the radium craze had died down, and institutional parameters were set around the use and abuse of radioactive products. Radio-phobia is an important cultural phenomena because it is the basis of nuclear fear, it offers the other side of the promise/peril binary, that properties of atomic energy such as radioactivity are not panacea, instead are to be feared. While Chapter 3 offers a deeper exploration of the acute fear surrounding radiation, this

period reveals the early emergence of a broader cultural anxiety toward radioactivity. As Obodovsky (2023) argues, widespread fear of radiation did not fully materialize until the atomic bombings of Japan, however, incidents such as the deaths of the Radium Girls and Eben Byers were instrumental in laying the groundwork for that shift in public perception. Radiophobia discourse not only sheds light on nuclear fear, but also underscores the potential for radioactive materials to be weaponized; an idea that becomes central in the next phase of nuclear energy discourse. In the 1936 horror film *The Invisible Ray*, scientist Dr. Janos Rukh discovers a powerful radioactive element with healing properties, only to realize its potential for destruction. After succumbing to radiation poisoning and descending into madness, Rukh weaponizes the element to exact revenge on those he believes have betrayed him. What this narrative foreshadows is not only the perilous byproducts of atomic energy, but the ability for scientists to play god and wield destructive power.

Atomic Energy

In popular culture, awareness of the potential of nuclear energy was somewhat muted minus a few pieces of literature. There is reporting by popular publications on the actual discoveries by physicists throughout the first half of the 20th century, however the public was more captivated with radium and x rays. The cultural response to the incremental discoveries and potential for atomic energy are largely positive, focused on the potency of the potential energy which could be unleashed. In a speech, Winston Churchill claimed that the potential for fission and fusion offered the ability to “drive a thousand horsepower engine for a whole year” (Churchill, 1931). This more so underscores the understanding of nuclear power at the time. A general positive ambivalence about the actual tangibility of nuclear energy, helping this of course was the momentum and fascination behind the discovery and applicability of X rays

(Obodovsky, 2023, p.55). Despite a few stories about energy from atoms creating a “white city,” with white being connoted as clean and futuristic, utopian discourses about atomic energy did not become ubiquitous until the 1950s (Weart, 2012, p.5).

One of the more salient cultural depictions of the potential for atomic energy is by way of literature. Prolific writer H.G. Wells, who often wrote about scientific themes, writes about the potential for an atomic bomb in his 1914 novel, *A World Set Free*. This book, a cautionary tale about the power of technology to destroy societies, uses different scientific terminology, but presents a very sound rationale about the destructive potential for atomic energy. For example, uranium exists in the novel as “Carolinium “, an element with scientific properties that allow for the first ever continually explosive weapon, which of course is prescriptive of the chain reactions of atomic weapons (Wells, 1914/2011, p.64). In the book, Wells narrates the discovery of atomic weapons, the onset of atomic war, the collapse of nation-states, and the eventual construction of a global utopian society from the ruins of that devastation. It serves as both a warning about atomic weapons, and a prediction about how destruction can forge peace.⁴ It is salient to note that the impact of Wells’ book coincided with the use of chemical gasses in WW1, signalling the increasing role of science in warfare (Weart, 2012, p.12). Wells’ narrative reflects an emerging modern risk consciousness, in which scientific progress becomes inseparable from the possibility of large-scale, technologically mediated destruction. This would be revealed in the coming decades.

⁴ Leo Szilard, a Manhattan Project scientist, and a key figure in configuring nuclear fission and chain reactions into a nuclear bomb, read *A World Set Free* in 1931. Szilard was so moved, he visited the author in the early 1930’s to speak with Wells about his theories explored in the novel, and ultimately decided that his work should be clearly dedicated to peaceful activities (Halasz et al., 1947). It is one of the reasons Szilard opposed the use of the atomic bomb in 1945, despite being a key figure in its development (Atomic Heritage Foundation, 2025).

Science and Technology Studies: Early Nuclear Energy

While the formal field of science and technology studies (STS) did not emerge until the 1960s, early 20th-century philosophical thought had already begun to grapple with the implications of modern physics. Many critiques of enlightenment rationality and the rise of scientific empiricism were rooted in concerns about epistemology and morality. At their core, these critiques questioned whether the pursuit of scientific truth was ethically neutral, or whether it risked becoming an amoral or even selfish enterprise. These concerns often took the form of metaphysical critiques, challenging the dominance of scientific rationalism as the primary mode of understanding the world. In the emerging atomic era, such concerns took on new urgency, as advances in physics suggested that scientific knowledge could fundamentally reshape society, politics, and warfare. The discovery of the atom and of radiation marked a profound rupture in the scientific order. As Campos (2015) notes, even as atoms entered public discourse as the foundational units of nature, scientific consensus still held that they were indivisible (p. 18). The discovery of natural radioactivity broke this assumption, revealing that matter itself was unstable and transformable. This realization unsettled the physics community and fueled broader philosophical anxieties that the basic building blocks of nature could be manipulated. If this was the case, then science as a subject didn't just describe the world, in a Darwinian way, it conferred unprecedented power upon those capable of wielding it.

For example, German-French Philosopher Albert Schweitzer was particularly disturbed by the application of scientific rationality in the early 20th century. Spurred by the horror of world war 1, Schweitzer saw a shift towards *realpolitik* and an abandonment of morality. Schweitzer believed that the new found and “exaggerated” faith in science at the turn of the 20th

century was at the expense of a level of ethical and moral humanism which should ground our behaviour (Blackwell, 1970). Along similar lines, and in more of a critique of evolutionary biology rather than nuclear physics, Henri Bergson put forth a critique of the mechanistic nature of scientific inquiry. Put simply, the way in which science treats life as simple matter to be studied in a pragmatic sense is an immoral act because it ultimately is in pursuit of an instrumental goal such as personal status, rather than a more open discovery (Bennett, 2012). While neither Schweitzer's nor Bergson's critiques were directed specifically at atomic science, their concerns reflect a broader moral framing of scientific modernity at the time, in which the growing power of science raised anxieties about the erosion of ethical responsibility.

Perhaps the most grounded writing on scientific progress in the early 20th century, with attention being paid to atomic science, is by famed logician Bertrand Russell. Much like early STS scholars, in the prophetically titled essay, *Icarus, or The Future of Science* (1924), Russell queried whether science would end up being a blessing or a curse for humanity. The way Russell sees it, science is two things, 1. A personal hubristic endeavour and, 2. A philosophical and imaginative endeavour (Russell, 1924/2024, Introduction). Within the physical sciences, Russell is especially concerned with how we've used rapid chemical and physical knowledge to build more sophisticated munitions for war, a precursor for what is to come. Along with his argument that the scientific and technological progress of telegraphs and communication technology aid nationalistic propaganda, Russell concludes that science in the early 20th century is not a boon for mankind, but rather works to centralize more power to those already at the top (Russell, 1924/2024, Conclusion). Russell continually explored the relationship between science and

ethics throughout his career, publishing *The Scientific Outlook* in 1931. In this book, Russell observes the scientific method closely.

In *The Scientific Outlook*, Russell weighs the positives and negatives of moving towards scientific empiricism. A few of the main benefits Russell observes via scientific progress is in the arena of human health and transportation. While Russell does mention the possibility of an atomic bomb, it is more so a metaphor for science based modernity rather than an outright prediction or concern. That being said he does warn that raw materials suitable for generating atomic energy should be in the possession of an international authority (Russell, 1931, p.248). This is to say, Russell's early 20th century ideas on science are centered on an ethical warning about the virtues of progress. This warning is prescient and foreshadows his manifesto written with Albert Einstein in 1955 about the consequences of all out nuclear war. Of course, to reach this level of organization and production, science would have to become an institution. In this sense, early critiques of science functioned primarily as ethical reflections on the application of scientific discoveries, rather than as comprehensive analyses of science's cultural significance. A departure from this perspective emerged with Robert Merton, who began to conceptualize scientific activity and its applications at a broader social level.

In his seminal essay *Science and the Social Order*, sociologist Robert K. Merton uses Nazi Germany to demonstrate how science had come to function as a cultural institution rather than a politically neutral tool. Merton argues that even within a hostile nationalist regime that promoted racialism, eugenics, and anti-intellectual rhetoric, the Nazi state nevertheless recognized science as a source of power (Merton, 1938). Despite its ideological constraints, the

regime maintained an instrumental respect for scientific knowledge and its capacity for pragmatic, evolving discovery (pp. 325–327). Science, in this sense, simultaneously serves dominant state ideologies while retaining the potential to exceed and unsettle them through its own internal norms and trajectories of development. As a constitutive element of the social order, science cannot be fully subordinated to politics. These tensions would become even more pronounced in the mid-twentieth century, as the destructive and world-altering consequences of scientific authority became undeniable with the advent of the atomic bomb.

Part 2: The Manhattan Project and The Atomic Bomb

The Manhattan Project

By 1938, successive breakthroughs in fission and chain reactions raised the alarming possibility that the Nazis might win the race to develop an atomic weapon. This became especially concerning by 1939, as World War II broke out. Just weeks before Germany invaded Poland, Albert Einstein, in collaboration with physicist Leó Szilárd, wrote a letter to U.S. President Franklin D. Roosevelt, warning of the potential for Nazi Germany to build such a weapon. He writes,

“In the course of the last four months it has been made probable—through the work of Joliot in France as well as Fermi and Szilard in America—that it may become possible to set up a nuclear chain reaction in a large mass of uranium by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future. This phenomenon would also lead to the construction of bombs, and it is conceivable—though much less certain—that extremely powerful

bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory (Einstein, 1939)."

Alongside fears that Germany's discovery of nuclear fission could be turned into a Nazi weapon, the MAUD Committee's confirmation that an atomic bomb was technically viable helped prompt President Roosevelt to authorize the development of an American atomic weapons program. In June of 1942, the U.S. Army initiated the Manhattan Project, a research program with the intention of developing nuclear weapons. The job of General Leslie Groves was to coordinate the migration of renowned nuclear physicists all over the world to Los Alamos, New Mexico, to work on the development of a nuclear weapon. J. Robert Oppenheimer was appointed to head up the Manhattan Project, which was seen to be a peculiar choice as he purportedly had communist sympathies and had never taken on such a large administrative role. Groves however believed that only Oppenheimer possessed the requisite knowledge to direct the project (Herken, 2002; Bird & Sherwin, 2005). Under the umbrella of the Manhattan Project, Oppenheimer recruited many of the world's best physicists to initiate research on how to develop the atomic bomb. Before the bomb could work, the scientists of the Manhattan Project first had to build a nuclear reactor with a self sustaining chain reaction.

The first pivotal moment came with the construction of the world's first operational nuclear reactor, led by Enrico Fermi and informed by Leo Szilárd's early theoretical work. Leo Szilárd is a central figure of this period, widely regarded as the first scientist to recognize the military potential inherent in nuclear fission. Displaying a prescient nuclear imagination, Szilárd was, as early as 1933, contemplating the splitting of atomic nuclei, constructing early particle

accelerators, and theorizing that the surplus emission of neutrons following a fission event could sustain a self-propagating chain reaction.(Rhodes, 1986; Lanouette & Silard, 1992). In 1942, Szilárd, along with his colleague, Dr. Enrico Fermi, an Italian Physicist who escaped Italy in response to Mussolini's race policies, developed the world's first nuclear reactor, predicated on the notion that if you kept bombarding and splitting nuclei it would cause a chain reaction which would emit boundless energy. This materialized in 1942 as the Chicago Pile-1, the world's first operational nuclear reactor as it had the first self-sustaining fission reaction. With Chicago Pile-1, Fermi and Szilard demonstrated the basis for the possibility of both civilian and military applications for nuclear power.

Oppenheimer and his colleagues decided to pursue two types of fission bombs, not knowing which would materialize first, plutonium (P-239) and uranium (U-235). What the development of Chicago pile one demonstrated was the ability to breed plutonium from U-238. U-235 on the other hand didn't need a novel reactor to process it, but required intense resources, electricity and labour to enrich it. Undertaking plutonium development was a site in Hanford, Oregon, and Oak Ridge, Tennessee was the site where U-235 was processed (Rhodes, 1986). Infrastructure was developed around these sites so the military could adequately produce enough of plutonium and uranium to build a bomb. The city of Oak Ridge, Tennessee, for example, did not exist in 1942, but by 1945 had a population of 75,000 (Reed, 2020, p.165). In Hanford, the scale of the Manhattan Project cannot be overstated. It encompassed over 30 research and production sites, employed approximately 100,000 workers, and cost an estimated \$2.2 billion in 1940s currency (The National WWII Museum, 2023). The most amazing feat is that the U.S government managed to keep this secret from the general public. While technicians were busy

producing enough fissile materials, at Los Alamos, Oppenheimer and his 2000 colleagues were trying to figure out how to build an operable bomb. This was the complex task at hand, and the deadline was set to have plans ready by the time Oppenheimer could amass enough material (Reed, 2020, p.224). By 1945, enough plutonium had been produced to test a bomb at the trinity test site in the Jornada del Muerto desert in New Mexico. This point marked the transition of nuclear fission from a theoretical and industrial project into an operational weapon with unprecedented political and existential consequences.

Trinity test

The technical differences between uranium and plutonium bombs shaped both the course of the Manhattan Project and the existential anxieties surrounding the first nuclear test. While plutonium-239 (P-239) proved easier to produce in large quantities than uranium-235 (U-235), the uranium bomb involved a much simpler design. In contrast, the more complex plutonium bomb was selected for testing at the Trinity site, a moment poised to either catalyze the end of the war or signal the dawn of a potentially civilization-ending technology. This is not a hyperbolic statement as a few scientists, most notably Edward Teller in 1942, raised the alarm that a fission reaction of that magnitude could light the earth's atmosphere (Moynihan, 2023). Further calculations leading up to the trinity test made the possibility seem far-fetched, although the fact remained that the Manhattan project scientists would not know what they had created until they tested it.

On July 16, 1945, the allied scientists detonated a 21 kiloton plutonium bomb in the Jornada del Muerto desert, and looked on in awe as a mushroom cloud rose over 7 miles into the atmosphere. Physicist Isidor Rabi noted that it was the longest 10 seconds he had ever

experience, that the flash of light was blinding, and post-test concluded that “A new thing had just been born; a new control; a new understanding of man, which man had acquired over nature” (Isidor Rabi, as cited in Rhodes, 1986, p. 672). In 1965, a solemn Oppenheimer revealed his true reaction to the trinity test, saying, “We knew the world would not be the same. A few people laughed, a few people cried, most people were silent. I remembered the line from the Hindu scripture, the Bhagavad-Gita. Vishnu is trying to persuade the Prince that he should do his duty and to impress him takes on his multi-armed form and says, ‘Now, I am become death, the destroyer of worlds.’ I suppose we all thought that one way or another” (Atomic Archive, n.d.).

The Dropping of the Atomic Bomb

Following the successful detonation at the Trinity Test, the U.S. military proceeded with the planned deployment of atomic bombs against Japan. On August 6th, 1945, the U.S. military dropped a uranium bomb called “little boy” on the city of Hiroshima, and on August 9th, dropped a plutonium bomb called “fat man” on Nagasaki. The devastation cannot be understated; most historians agree that the lowest possible fatality figure is around 110,000 and the highest it could be is upwards of 200,000 from the two bombings (Wellerstein, 2020). The true scale of the destruction of Japan was immense, as the United States undertook a severe firebombing campaign of the nation prior to the atom bombs, which had destroyed many major Japanese cities and killed hundreds of thousands of civilians (Werrell, 1996). The Japanese officially surrendered on August 15th, 1945. The Allies and the scientists at Los Alamos triumphed, the atomic bomb had worked. Yet with that success came the profound realization that nature itself had been reordered, and with it, the very structure of culture. The bomb was not only a weapon

but a symbol of a new era, as Boyer (1994) writes, the entire basis of civilization was fundamentally altered.

The descriptions of the bomb and its impact are harrowing. Little boy, for example, exploded 1900 feet above the ground, with explosion temperatures reaching 5400 degrees fahrenheit. This created a deadly fireball within a half mile of the explosion, killing people instantly and destroying homes; 70 of the 76 thousand buildings in Hiroshima were vaporized due to the blast (Kelly, 2007, p.331). The sheer horror of these images did not initially hit the west, and reports of “atomic illness” for those who survived the blast were initially censored in American media (p.318). Following the bombings, multiple Manhattan Project scientists, including Szilard, penned a letter to then President Truman, warning about the development of these destructive weapons. After the scale of the bomb’s destructive power became clear, leading figures of the Manhattan Project, including Hans Bethe and J. Robert Oppenheimer, devoted much of their postwar efforts to warning against the future use of atomic weapons (Schweber, 2000, p.156). The damage had been done, and the world was waking up to the reorientation of society around the destructive potential of atomic energy.

Communicative and Cultural Dimensions: The Manhattan Project & The Atomic Bomb

Introduction

This section briefly introduces the popular discourses that permeated Western culture in the immediate aftermath of the atomic bombings. While this chapter later engages with the formal risk-communication strategies of the Federal Civil Defense Administration (FCDA), the early post-1945 period was marked by a more diffuse and unsettled set of cultural responses. Before the Cold War had fully crystallized and nuclear war became a potential geopolitical

possibility, public discourse reflected a deeper anxiety about the sheer power and uncertainty of nuclear energy itself. The detonation of the atomic bomb in 1945 not only marked a decisive end to the Second World War, but also initiated a profound transformation in how science, technology, and power were imagined, communicated, and contested. Far from being understood solely as a military instrument, the bomb, and by extension the atom, was refigured as an autonomous force: capable of annihilating civilizations, reshaping nature, and inaugurating entirely new historical epochs. This section traces how these early post-bomb imaginaries took shape across popular media, official statements, and visual culture, laying the cultural groundwork for later, more formalized nuclear energy risk narratives.

The Atomic Bomb, Good and Bad Atom's, and the Production of Autonomous Technologies

In the immediate aftermath of the bombings of Hiroshima and Nagasaki, dominant public and governmental discourse framed the atomic bomb as a triumphant achievement of science. The Manhattan Project was celebrated not merely as a military success, but as a demonstration of the United States' ability to marshal scientific expertise, industrial capacity, and state coordination. This triumphalist narrative cast atomic energy as a testament to human progress. The official *Smyth Report*, which detailed the work of the Manhattan project and released just days after the bombings, exemplified this framing by emphasizing the technical ingenuity of the project and portrayed the bomb as the logical culmination of scientific rationality (Smyth, 1945). The reception of the atomic bomb however diverted from these frames, and what developed is a broader fear and fascination of the atom, the bomb, and the potential for self-annihilation.

During and immediately after the Manhattan Project, public discourse rapidly shifted from celebrating scientific achievement to constructing nuclear technology as an autonomous and morally ambiguous force. Perhaps this occurred when president Harry Truman broke the news from Hiroshima by saying, “It is an atomic bomb. It is a harnessing of the basic power of the universe” or perhaps it was reified by newspaper headlines at the time. For instance, the New York Times declared: “New Age Ushered: Day of Atomic Energy Hailed by President, Revealed by Weapon” (Shalett, 1945). Here, atomic weapons are not merely invented; they are revealed, as if they had existed independently, awaiting human discovery. Media representations framed the atomic bomb not solely as a product of human ingenuity, but as a self-acting, almost mythological entity capable of catalyzing a new epoch. A popular narrative at this time was that the bomb won the war, a development which scholars claim can be attributed to a concerted effort by the U.S. government to frame the bomb as an autonomous technological achievement rather than a human made chemical weapon (Canales, 2017; Evans, 2018). It is salient to note that discourses of the “mad scientist,” while prevalent, were not the target of public fear inasmuch as the scientists creation (Weart, 2012, p.37). On the day the bomb was dropped on Hiroshima, NBC radio presenter H.V. Kaltenborn referred to the dropping of the atom bomb as creating “Frankenstein” (p.56). This metaphor is apt because while Frankenstein is created by a scientist, the monster breaks from its institutional confines and lives a life of its own. The mythologization of the bomb further distanced itself from human ingenuity, and posits it more as a god-like figure which is either morally good for ending the war, or morally bad and a tool for self annihilation. For example, many religious fundamentalists framed the bomb as a signal of a coming apocalypse (Shils, 1956, p.71).

Anchoring the reductive framing of the atom bomb as an agentic technology is the singling out of the atom as an autonomous and important object of interrogation. The promise-peril binary beginning in the early 20th century takes on its evolutionary form in the framework of the atom. As early as the 1920's, scientists contemplated that the atom could spell either cosmic possibilities, or the end of the world (Weart, 2012, p.14). The introduction of mysticism and eschatological framing turned the atom from a particle into a mythic icon of something that could give, and something that could take away. The discourse of good and bad atoms was popularized through simplistic moral framings. A 1947 Time magazine article, "Good and Bad Atoms," exemplifies the tendency to imbue the atom with intrinsic moral qualities, independent of political or scientific context. Similarly, a 1945 New York Times article declared: "We Enter a New Era – the Atomic Age: Here is the Momentous Story of the Atom, Whose Energy Science Is Now Unleashed" (Davis, 1945). The language of "unleashing" implies that scientific work merely unlocked a preexisting, almost fated power. The article continues in the same vein many did at the time, that we have unlocked the secrets of the atom, ending with the statement, "Tremendous labors – probably greater than those involved in creating the atomic bomb – lie before mankind in harnessing this new and awe-inspiring power." In this discursive landscape, the atomic bomb, the atom and their explosive potential were not merely scientific phenomena, but cultural agents reimagined as autonomous forces, both feared and revered, marking the threshold of a new era. These discourses have contemporary counterparts through the framing of nuclear energy as an autonomous and authoritarian technology (Winner, 1977).

The Visual Politics of the Mushroom Cloud

From the first detonation at the Trinity Test site to the bombings of Hiroshima and Nagasaki, and later the nuclear weapons tests in the Nevada desert, the mushroom cloud endured as the symbol of the atomic age. The mushroom cloud is more than a physical byproduct of an atomic bomb, it is a cultural icon which encapsulates awe, terror, and epochal change. In the official report of the trinity test, the representative force of the mushroom cloud is revealed during the transcript of the countdown to detonation. The report goes, “Then, as the world teetered on the brink of a new age, Sam Allison’s voice cried, “Now!”” (Los Alamos National Library, accessed 2023). The depiction of the detonation was as a temporal rupture, signaling the birth of a new era, and reinforced through the visual culture that emerged in its aftermath. The August 20, 1945, issue of Life magazine featured iconic images of the Hiroshima and Nagasaki mushroom clouds, with stark captions: “Hiroshima. Atom Bomb No. 1. Obliterated it” and “Nagasaki. Atom Bomb No. 2. Disemboweled it” (Time inc., 1945). The mushroom cloud according to these descriptions framed the bombings of Japan not just as a record of violence, but as an autonomous force.

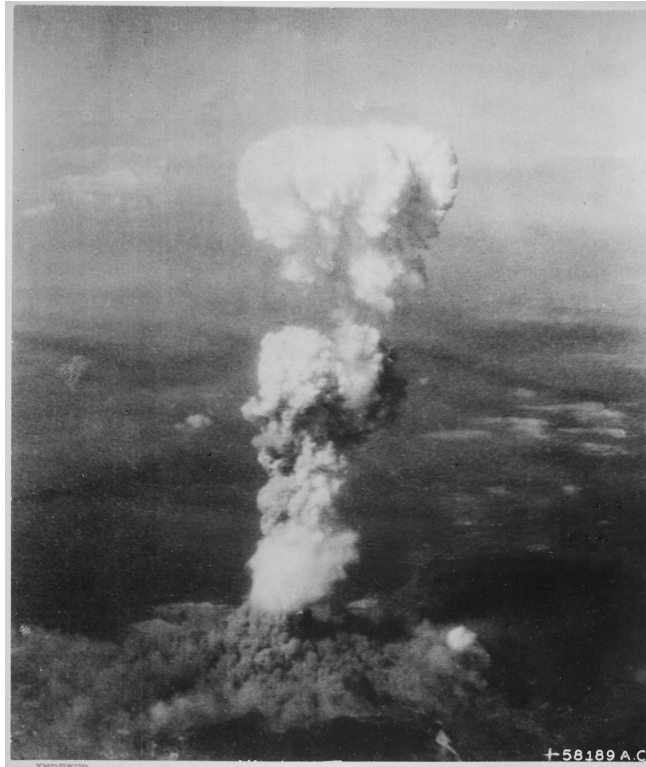


Figure 1.4. *Photograph taken of the mushroom cloud shortly after the bombing of Hiroshima on August 6, 1945.*
Source: National Archives and Records Administration via Wikimedia Commons (Public domain).

Scholars have explored how this imagery became entangled with discourses of death, and rebirth. Rosenthal (1991), in a semiotic analysis, argued that the cloud's form and function evoke procreation, through its symbolism of birthing of a new age. Taken literally, some qualified the bomb as "Oppenheimer's baby." The towering plume thus becomes a dual symbol: both a harbinger of death and an emblem of the birth of a new world. Some scholars argue that the aestheticization of the bomb is a way of hiding the rest of the devastating impact of nuclear weapons. For example, Hariman and Lucaites (2012) observe that the mushroom cloud conveniently displaces images of human suffering. Kirsch (1997) contends that the repetition and circulation of mushroom cloud imagery desensitizes audiences to its meaning, turning destruction into visual routine (p.245). This is illustrated through Warhol's 1963 artwork "Red

Explosion (or Atomic Bomb),” in which the constantly repeated imagery of the mushroom cloud is meant to critique both our fascination and detachment from destruction (Wellerstein, 2012). As a spectacle of sublime power (explored in the next section), the mushroom cloud endures as both a record of destruction, but as a visual artifact that shapes how nuclear bombs are revered, aestheticized, and ultimately normalized.

Risk Communication

It is salient here to also expand a quick articulation of risk communication during the early Cold War. The risk communication administered by the U.S. government under the FCDA (Federal Civil Defence Administration) as well in Canada did not resolve public fear surrounding nuclear energy, rather they effectively and efficiently spread imagery of nuclear disaster (Weart, 2012, p.72). Infamous films such as, *Duck and Cover* (1951), *The House in the Middle* (1954) and *About Fallout* (1955) were especially effective in spreading anxiety about full scale nuclear war. In the animated film *Duck and Cover*, for example, The FCDA creates a jingle and a routine for school aged children to follow, explained through the actions of risk-averse “Bert the Turtle.” The tone of the films, including the ones targeted at children, offered tips on survival, while tacitly implying the real potential for mass destruction. This risk communication is framed not only in a way that makes atomic war seem like an inevitability, but also underscores the embeddedness of nuclear fear and panic in everyday culture (Boyer, 1994; Oakes, 1994).

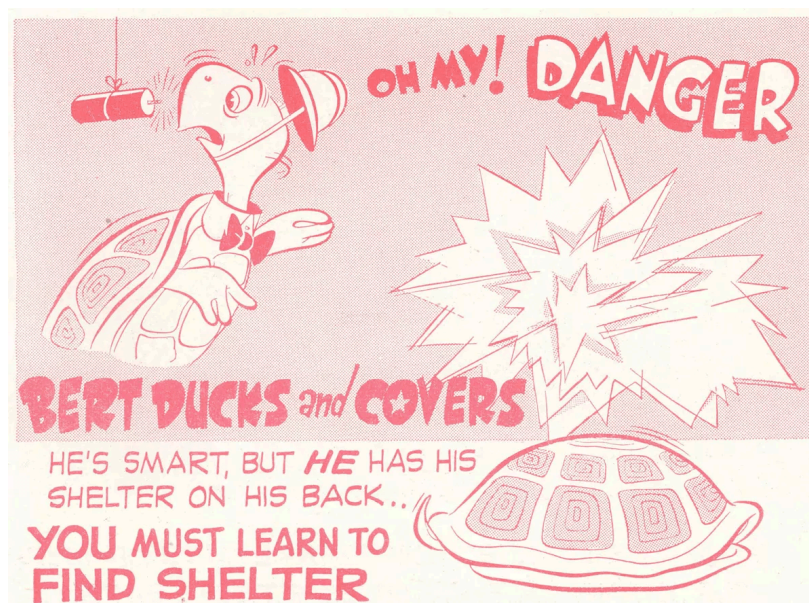


Figure 1.5. “Bert the Turtle” from the 1951 civil defense film *Duck and Cover*. Source: Archer Productions via Wikimedia Commons (Public domain).

Perhaps the clearest example of the FCDA heightening the risk perception of American citizens is through the construction and destruction of doom towns. In order to simulate the impact of an atomic weapon on a regular American neighborhood, the FCDA built fake towns throughout the 50's, nicknamed ‘doom towns,’ before dropping a massive bomb to accurately simulate the explosion. In his analysis of the cultural impact of doom towns, John Wills (2019) claims that while the FCDA’s objective was to find potential ways to survive nuclear blasts, the often broadcast tests reminded citizens about the devastating impacts of nuclear bombs (p.435). Not only this, but along with the information from FCDA films and mandated nuclear drills, the general public had a scalable reference to measure the destruction that nuclear war could bring. The legacy of doom towns and cold war risk communication has lasting impacts to this day, and its legacy informs much of the heightened fear around nuclear energy.

One of the tactics used by the Canadian officials, in line with the U.S. was to push the use of basement shelters to ward off the effects of a potential attack. According to the government, shelters were a rational preparation for nuclear attack. The Canadian pamphlet, signed by then prime minister John Diefenbaker, used this pragmatic rhetoric to encourage Canadians to start construction. As one passage reads, “Even an ordinary house provides some protection against radioactive fallout. The safest place inside is a corner of a basement. However, even in this part of the house there will not be, in most cases, sufficient protection to ensure the survival of the house holder and his family. It is therefore necessary to add to the protection afforded, and this can best be done by building a basement fallout shelter (Canadian Civil Defence Museum and Archives, n.d.). Later that same year the National Research Council of Canada funded an experiment documenting the building process based on the materials list and instructions. The builder, a mechanical engineer, concluded that the project would take an average family 250 hours, cost 380 dollars (around 3700 dollars today, adjusting for inflation), and may benefit from deviating from the original plans (Kent, 1961). The FCDA funded a similar study on shelter feasibility once built. The study had a family of five live in a basement fallout shelter for 14 days straight, the outcome concluding a rousing success. There were only reports of positive effects on the domestic unit, particularly for the father who spent more time getting to know his children, even helping his daughter out of her “mothers’ girl” persona (Vernon, 1959). This outcome, along with the Canadian study, confirmed the new synergy of militarization and privatization (McEnaney, 2020) and aided the ongoing responsabilization of the domestic unit for potential nuclear attack via risk communication.

Science and Technology Studies: The Manhattan Project & The Atomic Bomb

This section explores two key philosophies of science and technology interrogations following the development of the Manhattan Project and the detonation of the atomic bomb. The first is the interpretation of the bomb through the lens of the sublime, prompted by the scale of its material devastation. This explores how the bomb's overwhelming power and visual spectacle, exceeded conventional frameworks of understanding, generating discussions rooted in awe, terror, and existential uncertainty. By drawing on Kantian aesthetics, the sublime emerges as a critical tool for explaining how nuclear technology unsettled human perception, moral reasoning, and our relationship to the natural and technological world. The second philosophy this section explores is the beginning of what historians and STS scholars refer to as the era of Big Science. The Manhattan project re-characterized science through its state funding, institutional coordination, and military applicability. I further examine how nuclear physics shifted from individual curiosity to a systematically organized, bureaucratic endeavor, raising questions about agency, morality, and the institutional structure of modern knowledge production.

The Sublime

The swift introduction of atomic weapons into everyday culture prompted many scholars to align the experience with the sublime. Simply put, the sublime is an admission to the limits of materialism as a mode for explaining human experience. Morley (2021) writes that the sublime as a concept was developed to describe experiences that lay beyond human consciousness, an attempt to explain a phenomenon which triggered a sense of autonomy loss. There are many ways in which the sublime then is applied; to intense spiritual experiences, visualizing otherworldly beauty, experiencing natural disasters, and so on. Philosophically, through the work of Kant and others, the sublime encapsulates the beauty and terror of an experience which

reflects our own insecurity about human finiteness (Merritt, 2018, p. 4). This occurs both in an aesthetic sense and a material sense. Aesthetically, such as the icon of the mushroom cloud or the severely bright flash upon detonation, upsets the sensorial mediation between humans and their environment (Brady, 2013, p.183). In this vein, the bomb's aesthetics are so vast, violent, and alien that they destabilize perception and provoke a philosophical confrontation.

On a material level the atomic bomb brought forth the appraisal that humanity could in fact destroy itself. This is clearly muttered by Oppenheimer when he said, "Now I am become Death, the destroyer of worlds," but extends to scholars who grapple with how this new cultural order plays out. Nuclear war is sublime because we have no agency in this order, we as humans must submit to its sheer force (Ferguson, 1984, p.6). An apt theory which explores this nascent and violent introduction to the power of atomic weapons is the "nuclear uncanny." Masco (2013) posits the nuclear uncanny, as the temporal space between the psychology of imminent annihilation and the materiality of nuclear weapons (p.29). This was apparent from the first reactions to the Trinity Test. One observer of the test claimed that sitting 20 miles away from the blast site and watching a golf ball sized piece of uranium explode into 20 thousand tonnes of TNT was unbelievable (Brodie, 2023, p.41). In the aftermath of Hiroshima and Nagasaki, and throughout the Cold War, teetering on the edge of destruction, defined cultural consciousness. The sublime offers not just a framework for interpreting the overwhelming force of nuclear weapons, but a lens through which we understand how technological power can transcend comprehension, aesthetics, and morality all at once. The Sublime as a concept was generally reserved to nature, but the advent of the atomic bomb meant that humans had the capacity to cause large scale destruction.

Big Science

The Manhattan project was the culmination of the interaction between the U.S. military, the government, and scientists, and brought forth the era of “Big Science” (Galison & Hevly, 1992). According to Hughes (2002), the Manhattan project catalyzed the centralization and militarization of nuclear physics and academia, an organizational shift that, by many accounts, constitutes one of the most consequential scientific transformations in modern history. To conceptualize this, the Manhattan project was more than a research enterprise focused on building an atomic weapon. It was an industrial and engineering goliath as a result of the interplay between science and the military, where entire secret towns were built all toward one purpose (Brodie, 2023, p.23). Scientists therefore were no longer independent figures tinkering in a lab, they were products of state-sponsored large-scale science, and became entangled in the politics and ethics of their research on a much larger scale. Despite following mandates, the ability to manipulate atoms symbolized both the sheer ingenuity of scientists but also the depths of possible devastation, and put scientists at the forefront of the moral quandary of the atomic bombs. Many scientists after the Manhattan Project reflected on their work negatively. Oppenheimer allegedly told president Truman he had blood on his hands, and his colleague, physicist Joseph Rotblat, claims he left the Manhattan Project because for him science was now associated with death and destruction (Iskander, 2022). Lise Meitner refused to join the Manhattan project in the first place, claiming that she would not help build a bomb. These reactions are significant not just for their ethical implications, but because they reveal how scientists were embedded within a broader institutional system, a concern of philosophers of science and technology at the time.

Philosophy of science and technology scholars' concern with the atomic bomb centralizes around critiques of the militarization of science, and that science should not be divorced from broader cultural, ethical, and political contexts. In the previous section, philosophers critiqued the pursuit of scientific rationality as a selfish endeavour, but in this era, philosophers see science as much more than a personal undertaking, and more as a cultural paradigm. In a sense then, science divorces itself from individual will. For example, philosopher Thomas Kuhn argued that scientific development occurs along the lines of paradigm shifts, meaning that scientific change is culturally embedded (Kuhn, 1996). The culture of science is no longer driven by individual curiosity, but rather is a coordinated, institutionally bound, and bureaucratic subject (Polanyi, 1962). Building off this argument, an enduring concern of citizens in the post-bomb world was the idea that scientists could play god, and that ultimately the motivation of independent discovery could trump social ethics.

In this sense, the scientist is seen as operating outside social boundaries. In 1942, Robert K. Merton's essay, *The Normative Structure of Science*, was an attempt to complicate the assumption that scientists were isolated actors, instead proposing that science as an institution followed normative practices. These practices are universalism, communism, disinterestedness, and organized skepticism. Universalism refers to the personal characteristics of the scientist being devoid in scientific research, communism is treating scientific knowledge as a public good, disinterestedness is acting in the interest of scientific knowledge rather than personal gain, and organized skepticism believes that claims can be subject to scrutiny (Merton, 1942). While these are the normative structures of a perfect science, one must also remember that science and scientists exist within the confines and contexts of society, therefore, the geopolitical will of the

U.S., and the militarization of the institution of science set the stage for the use of atomic energy and atomic research .

Building on this shift from individual inquiry to institutionalized science, the role of technology also takes on an institutional form. In his famous essay, *The Question Concerning Technology* (1977), Heidegger rejects the idea that technology is simply a tool or a means to an end. He claims that technology “reveals” our relationship to the world. The reorientation of our relationship with morality, culture and our environment by way of the atomic bomb runs the risk of entrapping us in that particular mode of being, to the point where we think along the lines of technological instrumentality (Pp.46-49). Similar to Heidegger, but through a more broad and damning retrospective of the rise of technology since the industrial revolution, Jacques Ellul (1964) writes that institutionalization of technology is a dangerous prospect. He claims that when society doesn't have limitations around “techniques,” which refers to any technological method to achieve efficiency, it gives rise to an hierarchical and secretive society, guarded by technicians (Coleman, 2012, p.45). These technocratic systems become the dominant mode of society, and curtail individual freedom and alternative modes of being. What is clear in these accounts is a genuine fear that the power of scientific and technological order makes it so that humanity loses its grip on alternative modes of being. This reflects a moral and epistemological rupture, where humanity must now confront the idea that science and technology are not neutral forces, but deeply embedded in cultural and political paradigms. The Manhattan Project thus revealed that science was no longer merely a method of inquiry, but a cultural and political force capable of generating experiences that exceeded comprehension, agency, and moral certainty.

Conclusion

This chapter has traced the emergence of nuclear energy from its scientific origins in the late nineteenth century through its culmination in the atomic bombings of Hiroshima and Nagasaki in 1945. In doing so, it has argued that the defining features of nuclear energy politics, which are the binary between promise and peril, its intimate association with risk, and its capacity to unsettle cultural, moral, and political frameworks. From the discovery of X-rays and radioactivity to the institutional mobilization of Big Science under the Manhattan Project, nuclear energy developed alongside new ways of imagining power, uncertainty, and technological authority. These early moments reveal that nuclear energy has always been more than a technical phenomenon; it is a cultural object shaped through discourse. This chapter has shown that early public encounters with radiation and atomic science were characterized by a duality of fascination and fear. Radiomania and radiophobia emerged not as opposing anomalies, but as mutually constitutive discourses that established nuclear energy as simultaneously life-giving and life-threatening. This promise–peril binary intensified with the atomic bomb, as nuclear technology was reframed as an autonomous and era defining force. Through media narratives, visual culture, and political rhetoric, the atom was transformed into a mythic object, capable of ending wars, annihilating civilizations, or inaugurating new futures. The mushroom cloud, in particular, crystallized this shift, operating as a visual shorthand for both sublime power and existential vulnerability.

Philosophical and STS responses to the atomic bomb further underscored the depth of this rupture. Interpreted through the lens of the sublime, nuclear weapons exceeded conventional modes of understanding, destabilizing human perception, moral reasoning, and agency. At the same time, the Manhattan Project inaugurated an era of institutionalized science, binding

knowledge production to state power, and military imperatives. Together, these developments challenged the notion of science as neutral or purely progressive, revealing instead a technoscientific order deeply entangled with cultural paradigms. The bomb thus marked not only a material transformation of warfare, but an epistemological shift in how science, technology, and risk were understood in modern society. Chapter 2 builds directly on this foundation by examining the postwar transition of nuclear energy from weapon to civilian technology. While the rhetoric of “peaceful atoms” and civilian nuclear power promised a domestication of nuclear energy, this chapter foreshadows the rest of this project, in that nuclear technology never sheds its association with risk. The modern nuclear age does not represent a departure from the anxieties forged between 1896 and 1945, but their reconfiguration. As nuclear energy enters civilian grids, it remains qualified by the same cultural logics of danger, uncertainty, and authority established at its inception. Understanding this continuity is essential for analyzing contemporary nuclear discourse, where debates over safety, legitimacy, and trust remain inseparable from atomic histories.

Chapter 2

Nuclear Energy, 1946-Present

Introduction

The history of nuclear energy since 1946 is a story defined by a profound tension: this tension lies between destruction and progress, secrecy and spectacle, and utopia and dystopia. In the aftermath of Hiroshima and Nagasaki, scientists, policymakers, and citizens worldwide were confronted with a fundamental question. This question was, could the atom, engineered first as a weapon, be reimagined as a limitless energy supply? A day after Hiroshima, then first lady Eleanor Roosevelt wrote in her regular newspaper column, “This discovery may be of great commercial value someday. If wisely used, it may serve the purposes of peace. But for the moment we are chiefly concerned with its destructive power (The National WWII Museum, 2025).” This chapter traces that often contradictory goal, beginning with the immediate postwar search for peaceful applications of atomic energy and extending to today’s renewed enthusiasm for nuclear power amid the climate crisis and global warming. Over the last 80 years, political, cultural, environmental, and technological forces have shaped nuclear energy’s evolution from a military asset to a contested civilian technology and, later, to a central pillar in contemporary energy-transition policies. This history underscores that technologies are never permanently fixed to a single risk profile or meaning, but are continually redefined as their cultural contexts, and political purposes evolve over time.

This chapter opens with the early Cold War period, and examines how the U.S. The Atomic Energy Act of 1946 and the Atoms for Peace initiative attempted to recast the nation's nuclear identity after WW2, through emphasizing technological progress and peaceful applications of the atom. This extended to the cultural arena, as in the 1950s, there were a variety

of attempts to frame the atom as a symbol of modernity, progress, and boundless energy. The first section also moves away from the United States civilian nuclear programme, and analyses the rise and resistance to civilian nuclear power in nations such as Canada, France, the U.K and Japan. The first section ends by considering how the ideas of scholars Rachel Carson and Barry Commoner helped shape environmental discourses surrounding nuclear energy in the second half of the 20th century. The second section deals with the actual implementation of civilian nuclear energy; the successes, the failures, and the conflict between environmental groups and technological optimism. This section focuses on the acceleration of nuclear power development as a result of the 1973 oil crisis, the construction of the Canadian CANDU reactor, France's centralized nuclear mandate, and the rapid global spread of nuclear power through the 1970s. It also details the three major nuclear power plant meltdowns, TMI, Chernobyl, and Fukushima, and the risk discourses which emerged as a result of these events. Finally, the chapter situates contemporary nuclear energy debates within the broader context of climate change. The adaptability of technologies to the contexts in which they are situated is considered via the intellectual tradition of STS and the turn to technology, where scholars grapple with technological determinism, social constructivism, and co-constitutive theories.

Ultimately this chapter highlights that nuclear energy cannot be understood apart from the political, cultural, social systems in which it is embedded. In doing so, chapter 2 provides the historical and conceptual foundation necessary to understand nuclear energy not simply as a technology, but as a shifting social entity, continually remade by the fears imagined around it. This chapter is meant to cover a broad timeline of civilian nuclear development, and the critical conjunctions which produced the basis for the ways in which nuclear energy is still discussed

today. This also creates a segway into chapter 3, which focuses on the risk perceptions of nuclear energy with respect to the environment, health and political economy.

Part 3: Atoms for Peace & Civilian Nuclear Reactors

Introduction

During the 1950s at the height of Cold War tensions between the United States and the Soviet Union, civil defense discourse and the public fear of nuclear warfare overshadowed the atom's perceived promise. In order to assuage fears of atomic fallout, in conjunction with Civil Defense, the U.S. government launched the atoms for peace movement. This movement, while existing in various forms, from policy interventions to educational programming, is currently understood as an attempt to orient atomic culture around techno-utopianism. Between the reductive binary of nuclear war and atomic utopia, was a true struggle to redefine the coupling of military and peaceful applications of atomic energy. This section primarily focuses on the U.S., as it was the focal point of civilian nuclear energy development before the 1970s, and explores the critical political, cultural, and technological conjunctures which bred the emergence of a civilian nuclear reactor fleet.

Atoms for Peace?

Following the shock of the atomic bomb, the rapidly deteriorating relations between the United States and the Soviet Union shifted into a prolonged tension known as the Cold War. During the period from 1947 until the late 1980s, the two nations engaged in a massive build-up of nuclear arsenals, conducted weapons tests and sponsored proxy wars across the globe. Amid this climate of fear and escalation, alternative visions of the atom took shape as a potential source of boundless civilian energy. It was during this time that Lewis Strauss, Chairman of The

U.S. Atomic Energy Commission predicted that nuclear energy would one day become “too cheap to meter.” In a 1954 speech speaking about the potential for nuclear energy, he claimed,

“It is not too much to expect that our children will enjoy in their homes electrical energy too cheap to meter,—will know of great periodic regional famines in the world only as matters of history,—will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds,—and will experience a lifespan far longer than ours, as disease yields and man comes to understand what causes him to age. This is the forecast for an age of peace” (U.S. Nuclear Regulatory Commission, 2021).

The often utopian visions of atomic energy and the atom's transformative potential were adopted and celebrated by a world hungry for stability. This laid the groundwork for formal international efforts to reframe the atom as a tool for progress rather than destruction. The atoms for peace movement officially kicked off in 1953 when President Dwight D. Eisenhower stood before the United Nations, and made his famous declaration that some of the capabilities of the atom need to be channeled toward peaceful applications. The speech begins,

“To pause there would be to confirm the hopeless finality of a belief that two atomic colossi are doomed malevolently to eye each other indefinitely across a trembling world. To stop there would be to accept helplessly the probability of civilization destroyed, the annihilation of the irreplaceable heritage of mankind handed down to us from generation to generation, and the condemnation of mankind to begin all over again the age-old struggle upward from savagery towards decency, and right, and justice”

Then, Eisenhower changes the tone of the speech and proclaims,

“The United States knows that if the fearful trend of atomic military build-up can be reversed, this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind. The United States knows that peaceful power from atomic energy is no dream of the future. The capability, already proved, is here today” (Atomic Heritage Foundation, n.d.).

Behind the speech, there was real action to signal a commitment toward a peaceful application of atomic energy. The ultimate goal of atoms for peace was to push for the nuclear superpowers across the world to share atomic technology, with Eisenhower promising to offer uranium fuel to be placed under the jurisdiction of an International body (now the IAEA - International Atomic Energy Association) for civilian use (Hamblin, 2021, p.3). This initiative was not purely altruistic however; it served strategic and diplomatic purposes within the broader context of Cold War politics. Krige (2006) claims that that the object of the speech was ultimately to divert attention away from the military development of atomic weapons, and onto the atom as a benign hopeful object, reminiscent of earlier efforts to cast both the atom and the bomb in an autonomous light, explored in Chapter 1. At this point, the U.S. already had policy provisions in place to incentivize peaceful applications of the Atom as stated in the 1946 U.S. Atomic energy act. It reads, “Accordingly, it is hereby declared to be the policy of the people of the United States that, subject at all times to the paramount objective of assuring the common defense and security, the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace (Atomic Energy Act of 1946, 1946).” This policy, however, has been widely debated as a rhetorical cover for the actual activities unfolding within the U.S. nuclear program at the time.

Many scholars argue that *Atoms for Peace* was a continuation of earlier efforts to recast the image of American nuclear leadership in more benevolent terms. Hamblin (2021) writes that the United States used the production and distribution of radioisotopes in the late 1940's as a signal to the world that they had a vested interest in peaceful applications of atomic energy (p.18). The reality was that the demand for radioisotopes at the time was low and the U.S. needed a helpful distraction, as the lion share of raw radioactive materials was being consumed by their weapons program (p.21). For example, with the famed X-10 reactor in Oak Ridge, Tennessee, the U.S. emphasized its production of medical radioisotopes, while the Atomic Energy Commission (AEC) simultaneously covertly manufactured materials for nuclear weapons testing (Creager, 2013). This is relevant because civilian nuclear reactor development initially unfolded within a military framework, an origin that continues to blur the boundary between peaceful and military uses in public discourse. As Jacobs (2019) bluntly puts it, nuclear energy was invented to make nuclear weapons, generating electricity was a secondary concern (p.10). Beyond its military origins, the economic viability of civilian nuclear power also posed significant challenges for utility adoption.

Although the *Atoms for Peace* speech functioned in part to exaggerate the viability of atomic power and incentivize private investment in civilian reactors, utility companies in the 1950s were initially reluctant to shoulder the financial burden of nuclear development. (Maddock, 2010, p.90). Sustained government pressure, strengthened by subsidies and policy changes permitting private reactor ownership, and even resorting to threats in certain instances, ultimately compelled utility company participation despite the economic upside remaining bleak (Clarke, 1985, p.480; Martin, 1980, p. 68). Reluctance waived, and in 1957, Westinghouse

opened the United States' first commercial nuclear power plant in Pennsylvania, the Shippingport Atomic Power Station. The station operated for 25 years, and signalled an opportunity for scalable nuclear energy production.



Figure 2.1. *The Shippingport Atomic Power Station, the first American commercial nuclear power plant, opened in 1957. Public Domain via Wikimedia Commons.*

The shift toward commercial deployment occurred even as nuclear technology remained heavily prioritized for military purposes. By 1967, the United States had amassed approximately 32,000 nuclear warheads, underscoring the continued dominance of the weapons program. Yet that same year marked a turning point for civilian nuclear energy: U.S. utilities placed orders for 50 nuclear reactors, signaling a new phase of industrial commitment (Kristensen & Norris, 2015; International Atomic Energy Agency, n.d.). Between 1967 and 1973, the U.S. nuclear sector expanded rapidly, and by 1973, roughly 21,000 MWe of nuclear generating capacity was in operation (World Nuclear Association, n.d.). This surge was not merely a consequence of government policy; it was also driven by growing technical confidence. The successful

connection of the Shippingport Atomic Power Station to the grid in 1957 demonstrated that nuclear energy could reliably and safely produce electricity at scale, helping to dispel early skepticism and laying the groundwork for broader utility buy-in.

Canada

Chapters 4 and 5 focus on the Canadian nuclear energy industry, making it necessary to briefly outline our nation's development. The major accomplishment in Canada's nuclear energy history was the development of the CANDU (CANada Deuterium Uranium) reactor system at Chalk River Laboratories in northeast Ontario. The CANDU, a type of heavy water reactor, uses deuterium (a heavy hydrogen isotope) in place of regular hydrogen in H₂O, allowing it to operate without enriched uranium and enabling online refueling without shutdown. The viability of this system was demonstrated in 1962 when the NPD (Nuclear Power Demonstration) reactor, an early CANDU prototype, was connected to the grid, briefly becoming the world's most powerful nuclear reactor (Brooks, 2002). During this period, the Canadian government also established the Reactor Safety Advisory Committee (RSAC) to address emerging safety concerns, reflecting a parallel institutionalization of technical oversight.

Nuclear energy development at Chalk River is not without controversy. Reactors at the site underwent two serious accidents in 1952 and 1958 (Guillemette, 2022). The 1952 incident, often cited as the world's first nuclear reactor accident, occurred when mechanical failures led to a partial meltdown in the NRX reactor, releasing radioactive material and prompting a major cleanup effort (Health Canada, 2021). Beyond these accidents, and in line with the United States, military imperatives initially drove the advancement of civilian nuclear reactor technologies. Chalk River played a key role in the American nuclear weapons program. In addition to

supplying uranium, its heavy water reactors produced hundreds of kilograms of plutonium as a byproduct; material later used in many American nuclear weapons (Guillemette, 2022; Canadian Nuclear Safety Commission, 2025). It wasn't until 1965 that the Canadian government formally pledged to restrict nuclear exports only for peaceful purposes, and shifted focus to the promotion of its reactor technology for export abroad.

In the 1970s, Canada emerged as a global leader in nuclear technology, notably through the export of its CANDU reactor system (Sanz-Lafuente, 2023). One of the most prominent early recipients was India, where the Rajasthan-1 reactor was commissioned. Domestically, the industry saw major advancements as well; in 1971, the Pickering Generating Station came online with four reactors and a combined capacity of 2,060 MWe, briefly making it the largest nuclear facility in the world (Brooks, 2002). Despite Canada's commitment to peaceful uses of nuclear energy, the challenge of controlling how importing nations use nuclear technology remained unresolved. Following the purchase of a CANDU reactor, India successfully diverted plutonium for use in its first nuclear weapons test (Sanz-Lafuente, 2023, p. 37). This episode underscored the persistent and inextricable link between civilian nuclear reactors, weapons production, and national nuclear programs, a link that became increasingly scrutinized in the 1970s as environmentalists and non-proliferation activists fused in their opposition to the expansion of nuclear energy.

Nuclear Bomb Testing

While Chapter 3 offers an in-depth exploration of nuclear energy risk, it is important here to provide a brief historical overview of nuclear weapons development and testing during the 1950s and 1960s. The Trinity test at Los Alamos in 1945 marked the world's first detonation of a

nuclear device, initiating an era of rapid weapons development. Over the course of the Cold War, the United States and the Soviet Union, along with, to a lesser extent, the United Kingdom, France, China, and India, conducted more than 2,000 nuclear tests (United Nations, n.d.). These tests were carried out in various environments, including the atmosphere, underground, and underwater, each leaving behind significant radiological consequences. Several of these tests, explored throughout this section, are especially notable for their geopolitical, scientific, and environmental implications.

The 1950s and early 1960s marked the global peak of nuclear weapons testing. In 1952, the United States successfully detonated the world's first hydrogen bomb, ushering in a new and even more destructive phase of nuclear weapons development. Unlike fission bombs, which split heavy atomic nuclei, hydrogen bombs (or H-bombs) rely on nuclear fusion, which is the combining of light hydrogen isotopes under immense pressure in order to release greater energy. Fission weapons, while powerful, could not approach the scale of devastation produced by fusion devices. The first H-bomb test, code-named Mike, illustrated this. During Mike, The U.S. government detonated a 10.4 megaton H-Bomb from a remote control ship in the Marshall Islands and produced a colossal mushroom cloud reaching 57,000 feet into the sky and spanning roughly 100 miles in diameter at its widest point (PBS, n.d.). The most catastrophic test occurred just two years later on March 1, 1954, with the detonation of Castle Bravo, also in the Marshall Islands. At 15 megatons, the blast was approximately 1,000 times more powerful than the bomb dropped on Hiroshima. The resulting 25-mile-high mushroom cloud became a haunting symbol of the lasting damage inflicted on the Marshallese people. A recent *New York Times* article underscored the long-term radiological consequences of the test, reporting that residents living

within 100 miles of the explosion experienced acute radiation sickness and that rates of stillbirth among pregnant women doubled in the years that followed (Hennigan, 2024).

These findings underscore the profound human and environmental toll of nuclear weapons testing. The damage of American tests were not only felt abroad, as they extended to domestic communities as well. The Nevada desert, just north of Las Vegas, became the primary testing ground for the U.S. nuclear program, with a total of 928 detonations conducted between 1951 and 1992, including 90 in 1962 alone. By the late 1950s and early 1960s, growing public awareness of the health risks associated with radioactive fallout prompted increased scrutiny and protest. In response to mounting international and domestic pressure, the United States, the United Kingdom, and the Soviet Union signed the Partial Test Ban Treaty in 1963, prohibiting nuclear explosions in the atmosphere, underwater, and outer space (U.S. Department of State, n.d.).

Communicative and Cultural Dimensions: Atoms for Peace & Civilian Reactors

In the decade following Hiroshima, atomic energy became a deeply contested symbol in public discourse. The same technology that had annihilated entire cities was reimagined as a pathway to peace, progress, and modernity. This section examines how techno-utopian narratives emerged alongside, and often in direct response to, the trauma of nuclear violence. By tracing the veneration of the atom through media, consumer fantasies, and everyday practices, and juxtaposing these visions with the rise of anti-nuclear movements, it reveals how atomic optimism and atomic anxiety developed not as opposites, but as mutually constitutive forces shaping life in the atomic age.

Techno-Utopianism

After the bombing of Hiroshima, public messaging diverged, with some narratives emphasizing fear and devastation, while others framed the attack as justified by the potential implication of winning the war. A discourse that emerged from proponents of peaceful applications of atomic energy is techno-utopianism; the idea that atomic energy has the power to release humanity from its pre-modern shackles. There are a few theories as to why atomic utopia became an element of cold war culture. Maddock claims that the ideology of utopianism was borne out of the overconfident projections of civilian atomic energy, spurred by the propagandic goals of the atoms for peace movement (Maddock, 2010, p.90). Boyer (1985) contends that the preoccupation with peaceful applications of the atom, and envisioning fictional utopian versions of society, was a way of avoiding confronting the reality of what occurred in Hiroshima (p.122). What is clear, and is acknowledged across the theoretical spectrum, is that projections of atomic utopia exist in relation to the dystopic realities of atomic bomb testing and potential nuclear war.

The veneration of the atom is a key framing device with which the character of techno-utopianism took shape. In the mid 1950's "the atom" was talked about as if it were the next iteration of the steam engine, and instead of catalyzing an industrial revolution, notions of a societal "quantum leap" were being entertained (Krige, 2010, p.152). Framing the atom as a "peaceful" particle was an especially focused effort, and two promotional videos stand out as important discursive events in the reframing of the atom as a friend. The first, *A Is for Atom* (1952), is an award-winning animated film produced by General Electric, and was among the earliest visual media to present the atom as a powerful yet peaceful entity. One of the central rhetorical strategies used in the film is the anthropomorphization of atomic elements, each depicted as animated characters, to make the atom and atomic science approachable and

reassuring. Furthermore, through framing atomic discoveries in a language of wonder and miracle, the film redirects the immense power of the atom toward peaceful applications. The Atom is heralded as a potential power source for entire cities and modes of transportation and as a scientific virtuoso through the production of radio-isotopes and their effects on agriculture, industry and medicine.

In 1957, Disney released the influential educational film *Our Friend the Atom*, which further advanced the narrative that if you make friends with the atom, its potential energy is a pathway to modernity. Throughout the film, the atom is presented as a mysterious but ultimately tameable entity, and at one point in the film, The narrator confidently claims, “The atomic reactor then gives us a chance to make the atomic genie our friend” (*Disneyland - Our Friend the Atom*, 1957). This film uses the wish granting genie as an allegory of the barrier to modernity. The film signifies the rhetorical imperative to pacify the atom not as a weapon for war, but for human flourishing. As Mechling & Mechling (1995) explain, *Our Friend the Atom* added cultural legitimacy to the workings of government programs attempting to develop civilian applications for nuclear energy. This film was also part of a push to return the atom to its status as a natural occurring entity, rather than an artificial source used for bombing and intimidation. Beyond P.R. strategies, these films were important in establishing a language of atoms and atomic energy that diverted from civil defense risk communication.

On a material level, atomic utopia meant a civilian nuclear energy program and using radioisotopes for peaceful purposes, and culturally, these took on ideological characteristics of progress and hope. What stirred the public the most was the purported “boundless” energy potential of the atom, the applications of which could apply to a variety of different things, such

as nuclear powered cars. Ford and Studebaker even went as far as to produce prototypes of atomic cars. The Nucleon and the Astral respectively, could run for thousands of miles without a refuel, and perhaps maybe even fly (Daugherty, 2024).

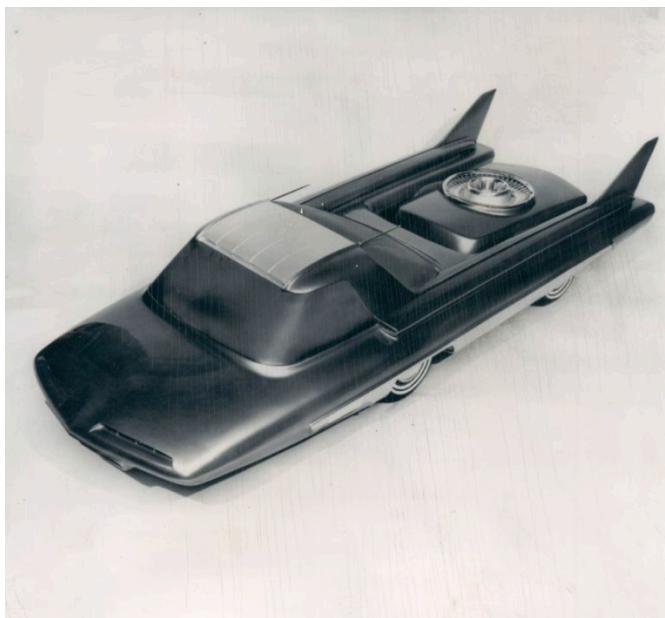


Figure 2.2. The Ford Nucleon, a 1958 concept car, envisioned a future where automobiles were powered by compact nuclear reactors, reflecting the era's optimism about atomic energy. *The Ford Motor Company via Wikimedia Commons.*

While automakers imagined futuristic nuclear-powered vehicles on the roads, the wider public wove atomic imagery and experiences into everyday leisure and entertainment. Atomic-themed restaurants, hotels, and even guided trips to Las Vegas for “atomic tourism” exemplified the everyday embrace of nuclear culture. Atomic objects became central pillars of this, as Anaïs and Walby (2016) argue that witnessing the Nevada Test Site explosions was more than spectacle, rather it grounded the material and social relations that defined life in the atomic age. This dynamic was made explicit in Las Vegas, where for twelve years crowds gathered roughly once every three weeks to watch mushroom clouds billow out of the Nevada desert from the nuclear test site (PBS, n.d.). Spectators watched in awe and marveled at the power of the atom while indigenous communities suffered health impacts from the radioactive clouds which

blew downwind from the test site, revealing the reality that utopian visions frequently coexist with, or give rise to, dystopian realities (Frohmborg et al., 2000).

The utopian–dystopian binary exposes a central paradox in the technological idealism that surrounded the atomic age. William Kinsella captures this tension through the theme of entelechy, one of his four master themes of nuclear energy. Entelechy refers to the realization of potential or a sense of an inevitable destiny (Kinsella, 2005, p. 64). In nuclear energy discourse, this idea reflects the belief that atomic energy was destined to fulfill a particular future. While utopian narratives imagined a peaceful, abundant atomic future, the actual entelechy of nuclear technology in the 1950s and 1960s was enmeshed with fatalism and militarization. The atom did not fulfill its potential as a peaceful and emancipatory particle during this period, but rather fueled weapons testing, and anxieties about nuclear holocaust.

Anti-Nuke

In the 1950s, alongside hopeful and utopian predictions for the atom, was a cohort of global citizens who began to rise up against nuclear weapons proliferation and testing. In Japan, the UK, the U.S., West Germany, and elsewhere, concerned individuals protested and rallied around the end of nuclear testing. The 1954 aforementioned Castle Bravo test revealed the dystopian reality of atomic energy misuse, energized anti-nuke protests, and outraged people all over the world. The impact of this test reached international notoriety after a Japanese fishing vessel, ironically named the Lucky Dragon, was unknowingly positioned within the fallout radius of the H-bomb. The ship returned to Japan with a crew suffering from acute radiation sickness, and a healthy stock of radioactive fish on board. The U.S. government responded defensively, downplaying the incident, accusing the fishermen of espionage, and offering

contradictory public statements (Maddock, 2010). The Lucky Dragon incident helped fuse public concerns about testing with a larger critique of nuclear proliferation, laying the discursive groundwork for modern anti-nuclear movements.

The central tenet of anti-nuke discourse is that there is no peace with proliferation. Globally, anti-nuclear protests erupted in cities around the world, including Japan, where the movement was fueled by the coupling of the lingering trauma of Hiroshima and Nagasaki, and the environmental and human toll of the Castle Bravo fallout disaster (Higuchi, 2008). In the U.K., anti-nuke sentiment was high due to resistance for their own national nuclear testing program. The U.K.'s detonation of an H-bomb during the Grapple nuclear tests sparked public opposition, with polls indicating that half of Britons opposed the tests and catalyzed the founding of the Campaign for Nuclear Disarmament (CND) (Steele, 2017). The CND organized demonstrations en masse against the proliferation of nuclear weapons, including a well known recurring march between London and Aldermaston, the site for England's nuclear weapons research facility (*People's history of CND*, n.d.). These marches drew tens of thousands of concerned citizens, holding up signs featuring CND's logo, the now famous peace sign. Across the pond, In the U.S., the group Women Strike for Peace (WSP) organized a national protest in 1961, with over 50,000 women in 60 cities across the U.S. demanding an end to nuclear weapons testing. Their official group policy at the time echoed the concerns of other movements, with one passage reading, "We represent a resolute stand of women in the United States against the unprecedented threat of life from nuclear holocaust" (Women Strike for Peace, 1962).

Not all demonstrations were grass roots movements, as key public intellectuals also joined anti-nuke movements. Philosopher Bertrand Russell was one of the founders of the committee of a 100, an organization which aimed to increase pressure on the U.K. government in the 1960s to disarm, through acts of civil disobedience. In one occupation of Trafalgar Square, an 88 year old Russell and his wife Edith sat in the middle of the busy London street with other protesters for hours (McMaster University Library, n.d.). The SANE (National Committee for a Sane Nuclear Policy) organization also had leading public intellectuals, such as Martin Luther King jr, pediatrician, olympian and political activist, Benjamin Spock, and journalist and professor, Norman Cousins. SANE garnered support because along with grassroots methods, it used more official communications channels, such as running full page ads in the New York Times denouncing weapons proliferation and nuclear culture (Martin Luther King, Jr. Research and Education Institute, n.d.). Whether led by public intellectuals or everyday citizens, these movements revealed that opposition to nuclear proliferation was not confined to any single nation but was instead a shared global discourse, uniting grassroots activism and intellectual resistance in a collective demand for disarmament and peace. It also reveals a deep fracture between the hope for any peaceful application of the atom, and the reality of its use in the 1950s and early 1960s as a vehicle for increasingly destructive weapons.

Science and Technology Studies: Atoms for Peace & Civilian Nuclear Reactors

This era in the philosophy/sociology of science was prescient, because it not only continued to identify and question the epistemological directives of science, but several key books took political and moral stances against the scientific establishment in the name of ecology. There was still a continuation of earlier work, such as analyses of the structure and hierarchy of scientific knowledge. Figures such as Thomas Kuhn, who devised his paradigm

model, argued the rules of science, the methods, knowledge and tools which inform a scientist's work, exist within the context of the specific paradigm in which they operate (Kuhn, 1970, p.46). According to Kuhn, scientists must abide by the dominant paradigm, because differing paradigms speak an entirely different language; they are incommensurable. As Kuhn notes, their “standard and definitions of science are not the same (p.148).” What becomes important in the critiques of science in this era is unraveling the specific scientific and institutional paradigms which allow for the release of toxic matter and contaminants into the environment. In this regard, two key figures emerged; Rachel Carson and Barry Commoner.

In 1962, Rachel Carson released her seminal book, *Silent Spring*. This book, while about DDT, shed light on the harms of the use of toxic chemicals in the name of science. The book helped spur an environmentalist movement and aided in pressuring the government to eventually ban DDT in the U.S in 1972. While not directly about nuclear energy, *Silent Spring* acted as an important academic critique of nuclear energy in two distinct ways. First it spoke to the danger of invisible, cumulative harms, and second, it empowered a rhetorical strategy which questioned scientific and political hubris surrounding the environment. The dangers of invisible, cumulative harms emerged within a scientific paradigm characterized by an unmitigated faith in science's ability to deliver quick solutions. Herbicides and DDT, touted as weed and insect killers, were incredibly damaging chemicals to the local environment. Within this paradigm of scientific optimism, Carson draws deliberate parallels between chemical exposure and radiation. Scientifically, chemicals such as DDT and radiation are both “uncouplers” as Carson explains, which is a process by which both interfere with normal cell production in living things (Carson, 2002, p. 203). On a physical level, the uncoupling happens when radiation destroys cells

outright, or when DDT/herbicides/insecticides disrupt the energy-producing processes within the cells of organisms that absorb it (p.204). Examples we can point to for radiation are the stillbirths observed in the Bikini Atoll, years after the American Castle Bravo tests in the Pacific (Hennigan, 2024), or for DDT/herbicides/insecticides, the countless examples uncovered in *Silent spring*: adverse effects for bird reproduction, blindness in fish, effects on mammal reproduction, etc. (Carson, 2002, p.76, 135, 207). What is central to this comparison is attention must be paid to cumulative, non-acute harms, particularly the slow and damaging accumulation of toxic substances in the environment in the name of “scientific progress.”

Ideologically, these comparisons serve a larger argument throughout the book, which is uncovering the fragility and interconnectedness of all living things, and the need to challenge dominant scientific and institutional paradigms which perpetuate environmental harms. With respect to Kuhn eight years before his theories, it exemplifies the incommensurate nature of differing paradigms. Carson spends the last chapter of *Silent Spring* introducing scientific research, often nature based, which averts the use of the toxic chemicals she critiques throughout the book. Alternative paradigmatic visions for the role of science are both attempting to reverse the use of toxins which have a lasting environmental impact, and attempting to raise ecological awareness and ethical responsibility to not self-inflict damage in the name of scientific progress, an idea extremely prescient with respect to radiation. Within this broader rethinking of science’s ethical and ecological responsibilities, figures such as Barry Commoner emerge as a central critic of techno-culture driven environmental harm.

Along with Carson, biologist and politician Barry Commoner, was a leading voice in advocating that synthetic or man made pollutants broke the laws of ecology. His book, *The*

Closing Circle (1971), argued that the burgeoning environmental crisis first and foremost was a breakdown between nature and culture, as humans extract, use and pollute without respecting the cyclical nature of ecological systems. Commoner believed science was a vehicle to accomplish human desires of war, consumption, and extraction, and naturally upset the delicate cycle of the environment (Pp.20-21). Commoner's writes that human made toxins and waste upset the interconnectedness of every life form because ecological systems are not equipped to integrate and dispose of them. In terms of radiation, the lack of awareness of the integration of ecological systems means that while a domestic test may be sold as emitting radiation in an area of the desert devoid of life, it is often brought to urban areas through other means, such as through radioactive clouds. These clouds can rain down on crops and irradiate the soil, which in turn irradiates the food we eat (p.45). Commoner claims that the often subsequent debate about safe limits of radiation exposure are merely a materialization of our initial fundamental disconnect with ecology.

The critiques advanced by Carson and Commoner reveal how the dangers of nuclear testing were products of a dominant scientific paradigm that privileged humanity over ecology. Their interventions exposed how invisible, cumulative harms, whether chemical or radiological, were rendered acceptable within a framework that treated the environment as an externality rather than a living system. Both these books use the case studies of toxins to signal the ecological breakdown between nature and culture, and had a profound effect on the adoption of nuclear energy in the 20th century, due to the nascent environmentalist movement which both these figures helped spur. In the next section, I explore the development of civilian energy in the face of environmentalism and ecology.

Part 4: The Modern Nuclear Industry & the Energy Transition

The modern nuclear energy industry is in fact not modern at all. More than half the world's nuclear reactors are over 30 years old, and in the U.S. the mean reactor age is 42 (U.S. Energy Information Administration, 2023). While this may not be old in the context of energy infrastructure, most nuclear reactors have an operational lifespan of 30–40 years. Despite age-related concerns, reactor performance has generally remained stable across their licensed operating periods. (World Nuclear Association, 2025). There is currently a push to extend the life of reactors through licensing refurbishments, a process which has been very successful in Canada, with the success of the Darlington nuclear reactor refurbishment, and the green light for the Pickering and Bruce Power refurbishment projects (Ontario Power Generation, n.d.; Bruce Power, n.d.). The wave of reactor refurbishments and the contemporary reevaluation of nuclear energy reflect a pivotal moment in energy history. Much of today's global nuclear fleet was built between the 1970s and 1990s, a period of rapid development driven largely by the 1973 oil embargo.

The Oil Crisis and Global Development

In 1973, Arab members of the Organization of the Petroleum Exporting Countries (OPEC) imposed an oil embargo against the United States in retaliation for its support of Israel during the Arab–Israeli War (U.S. Department of State, Office of the Historian, n.d.). These actions sent oil prices skyrocketing, questioned the United States' heavy reliance on foreign fossil fuels, and created incentive for the increased implementation of civilian nuclear energy. It is not entirely accurate to say that nuclear energy was not a commercially viable product before the oil crisis. Positive development in the 1960s meant that by 1970 there were 90 nuclear

reactors operating in 15 countries across the world. The 1973 oil crisis accelerated interest in civilian nuclear energy, as oil had supplied roughly 25% of global electricity before the shock, leaving a significant void that an alternative energy source could plausibly fill (Toth & Rogner, 2006). The boost to nuclear energy from the oil crisis meant that by 1980 there were 253 operational reactors in 22 countries, with the electricity output from nuclear energy increasing globally from 16,500 MWe pre crisis to 135,000 MWe post crisis (Char & Csik, 1987). Around 40% of today's nuclear reactors were built in response to the oil crisis (Gaspar, 2022), with certain nations succeeding more than others in terms of a civilian nuclear energy program.

France

Perhaps no country adopted nuclear energy more seriously than France, as in 1974, the government under Pierre Messmer launched the Messmer plan, which was an all encompassing effort to nationalize energy around nuclear production. The history of French nuclear development wasn't just concentrated in the 1970s. France had rich nuclear energy development after the war, as the CEA (Commissariat à l' énergie atomique) worked to produce two heavy water reactors by 1949 (Kojima, 2019, p.33). This was part of a larger effort to recapture cultural identity through technological prowess. The common discourse at the time was "Le rayonnement de la France," a moniker which literally means the radiance of France, but interchangeably used figuratively as a suggestion of technological grandeur and national pride (Hecht, 2009, p.2). The French nuclear program stagnated in the 1950s following the removal of CEA chief Frédéric Joliot-Curie for his communist affiliations. Despite technical advances in the subsequent decades, France remained 80% dependent on foreign energy by 1973 (p.37).

In the 1970s, French prime minister Pierre Messmer decided to fully adopt nuclear energy after the oil shock (Le Gros, 2020). “The Messmer Plan,” initiated what we currently see as French nuclear power dominance. This was ultimately achieved through a centralized state mandate and the framing of nuclear energy as a national project (Toke et al., 2021, p.92). France was able to build 58 standardized reactors over 25 years, which statistically meant that electricity generation from nuclear energy increased from 8% in 1973 to 75% in 1990; energy generation from oil in that same period dropped from 43% to 4% (Kojima, 2019, p.37). What centralization and standardization meant for France is that every process from construction to maintenance remained consistent, meaning they could develop nuclear energy fairly cheaply and efficiently. The French case is somewhat of an outlier, especially when you get into the 1980s and 90s; decades rife with backlash and protest from environmental groups.

Environmental Resistance

While today nuclear energy development is often framed within green policies predicated on energy decarbonization, the spurt in civilian nuclear power in the 1970s came with a resistance on the basis of environmental protection. A few major events signalled that individuals were increasingly concerned with how humans were interacting with the environment. Catastrophic moments like the great smog in London in the 50’s, the Santa Barbara oil spill and chemical fire in the Cuyahoga River in 1969, and the Bhopal disaster in the 1980s solidified the idea that technological modernity came at the cost of environmental protection. In an effort to rebuke the ways in which humanity was subjecting the environment to pollution, the world’s first earth day erupted in 1970. Other important events in the 1970s were the establishment of organizations such as Greenpeace and the Sierra Club, the creation of the EPA (environmental protection agency) in the United States, and nascent renewable technologies such as solar power,

entering the fray. The anti-nuke crowds of the 1950s and 60s joined the environmentalists in the 1970s, in an all out rejection of any application of nuclear power.

The no nuke movement enmeshed with the environmental movement in large part because radiation was understood alongside other industrial toxins as another form of pollution, thereby situating nuclear risk within a broader, emerging ecological consciousness (Weart, 2012; Foley, 2016). Beyond radiation, the growing environmental impact of uranium mining and nuclear testing were also reasons for the new ecological direction of the anti-nuke movement (Gulliver, 2023). There are many reasons why orders for new nuclear power stations peaked by 1975 and began to decline, including economic stagnation, high construction costs, and longer, more arduous licensing processes, but the key contributing factor was the nascent environmental movement. Across the western world, protests and occupations enveloped proposed nuclear energy sites. The surge in grassroots opposition was pronounced in Western Europe, where anti-nuclear activism helped lay the groundwork for broader political movements. In his book *Greening Democracy* (2017), Milder charts the rise of West German environmental resistance to nuclear energy as a catalyst for green politics in the country, using the famous Whyle protests as his case study. The Whyle protests were extremely effective as the 8 month occupation of the site staved off construction of a proposed reactor (Fröhlig, 2020).

Even in France, where nuclear energy support was high, there was a healthy environmental pushback for reactor construction. French anti-nuclear activities manifested in proposed reactor site protests and marches. Operating under the broader umbrella of environmentalism, groups such as Friends of the Earth (*Les Amis de la Terre*) and *Survivre*

coordinated anti-nuclear efforts in France, successfully delaying some nuclear power projects, though ultimately failing to prevent the commissioning of a power plant in 1977 (Fröhlig, 2020). In the United States, Groups like Friends of the Earth and the Sierra Club had massive sway in public discourse throughout the 1970s, and often folded anti-nuclear sentiment within a broader framework of environmental protection and conservation. The U.S. government did little to push back against protester concerns. Because the general focus of the AEC (atomic energy commission) in the U.S. was weapons proliferation, very little attention was paid to researching potential radiation hazards of civilian reactors (Cohn, 1997, p.88). The lax regulatory standards for nuclear reactors in the U.S. reflected earlier apathetic discourses to the impact of the atomic bomb, leading to a homogenized group of nuclear critics, who didn't trust any uses of nuclear energy.

These broader dynamics of environmental opposition in the United States crystallized most clearly around specific reactor sites, none more consequential than the controversy surrounding the Diablo Canyon Power Plant in California. As historian Susan Schrepfer (1992) points out, an internal conflict in the Sierra Club on whether to support the construction of Diablo Canyon led to the formation of Friends of the Earth, who took a staunch opposition to the plant. Since this episode the Sierra Club has reiterated its commitment to anti-nuclear, even signalling its stance currently on its website. Diablo Canyon, to this day, remains an important protest in the history of American anti-nuclear sentiment. In an article uncovering the oral histories of the protests, Historian John Wills writes that much of the reason for protest was a genuine concern for the fate of biodiversity around the plant (Wills, 2000, p.48). Similarly, in Canada, biodiversity protection served as a central framing device in protests against a proposed

nuclear reactor site in Nova Scotia during the 1970s (Leeming, 2014). The Canadian reactor was never built, and these protests, alongside others internationally, anticipated the environmental concerns that would later be amplified by catastrophic nuclear accidents in subsequent decades.

Meltdowns

Public unease toward nuclear reactors persists globally, shaped by the legacy of major accidents such as Three Mile Island, Chernobyl, and Fukushima. While there were nuclear accidents before these events, such as the 1957 Windscale fire in the U.K., these three meltdowns are significant because of their widespread impact on the political, discursive and cultural aspects of nuclear energy risk. On March 28, 1979, the unit two reactor at the Three Mile Island Nuclear Generating Station (TMI), melted down. Due to a mechanical failure, there was a sudden loss of coolant (water) that removes heat from the reactor core, leading to an automatic reactor shutdown. A stuck open relief valve meant that operators failed to see the loss of coolant, and led to the water level in the pressure vessel dropping and the reactor core overheating (U.S. Nuclear Regulatory Commission, n.d.). The release of radioactive materials during the meltdown was minimal and had negligible health impacts, however the clean up of the accident took around 12 years and cost nearly 1 billion dollars (World Nuclear Association, 2022). This event spurred the U.S. Nuclear Regulatory Commission to tighten their regulatory grip on nuclear energy, focusing on emergency response planning and reactor safety (U.S. Nuclear Regulatory Commission, n.d.). The impacts of this are explored further in Chapter 3, however TMI symbolized the beginning of the decline of nuclear energy development in the 21st century.

Seven years after the Three Mile Island incident, the world witnessed a catastrophic nuclear disaster, in the then Soviet Union (currently Ukraine). On April 26, 1986, during a routine safety test, operators at the Chernobyl Nuclear Power Plant inadvertently caused a critical failure in Reactor 4, leading to a core meltdown. The resulting explosion and radiation release led to the deaths of plant workers and firefighters from acute radiation sickness. The flawed reactor design was unique to the Eastern bloc, as when control rods were inserted into the reactor, a mechanism for regulating the nuclear chain reaction, the reactor responded with a surge of power. This occurred after the operator had disabled automatic shutdown mechanisms for testing purposes, leading to high steam production and an increase in pressure until eventually caused multiple explosions which ejected radioactive materials (World Nuclear Association, 2025b). The most consequential impacts of Chernobyl were the health effects, as the reactor released large amounts of the radioisotopes iodine-131, cesium-134, and cesium-137. The immediate impact was felt by the workers, 600 of which were on site that day. Of the 600, 134 suffered acute radiation sickness, and 28 died in the first 3 months (Canadian Nuclear Safety Commission, 2025).

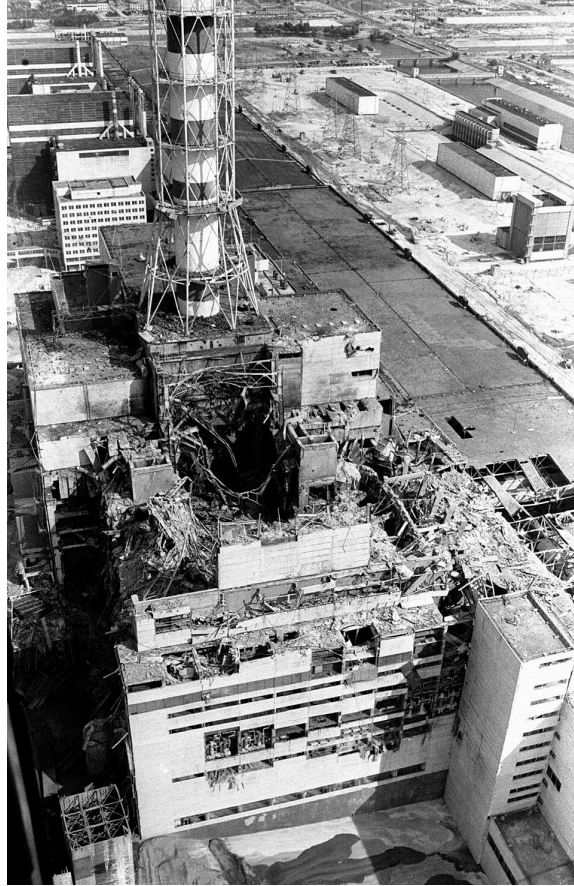


Figure 2.3. Aerial view of the destroyed Reactor 4 at the Chernobyl Nuclear Power Plant, taken several months after the explosion. *Photo credit: IAEA Imagebank via Wikimedia Commons.*

The political and economic fallout of Chernobyl is explored further in Chapter 3, however, the simple fact is that coupled with TMI, post Chernobyl nuclear energy development essentially reached a standstill. After a long period of civilian nuclear energy development stagnation, and several nuclear energy bans across Europe (Denmark, Italy, Switzerland), conversations of a nuclear energy renaissance began to circulate. Momentum toward nuclear energy picked up in the 21st century due to the increase of national energy policies integrating net zero plans. In 2011 however, a tsunami triggered a nuclear meltdown at the Fukushima Nuclear Plant in Japan, reigniting fears over the catastrophic potential of nuclear energy.

On March 11, 2011, a major earthquake off the coast of Japan shook the nation, however, the people in charge of the Fukushima Daiichi nuclear power plant reacted quickly and successfully shut down Units 1, 2, and 3 using backup emergency generators (Units 4, 5, and 6 were out of operation for maintenance) (Lochbaum et al, 2014, p. 15). The earthquake triggered a tsunami, and a wave nearly 50 feet high hit the power plant and flooded the backup power systems while reactor units 1–3 were in the process of shutting down (p.18). Without power, the reactor cores could not keep cooling, leading them to overheat and meltdown. All three cores released radioactive materials, leading to evacuations of the surrounding area (World Nuclear Association, 2024). Fukushima in terms of destructive scale reached the levels of Chernobyl, a reality that the world believed they were beyond.

New Nuclear

Over recent decades, national energy policies have increasingly prioritized carbon-dioxide-free electricity and electrification, marking a shift away from fossil fuels. Nuclear energy has benefitted from this transition after experiencing a significant downturn in the 1990s following the Chernobyl disaster. Heightened public fears, stricter regulatory standards, and escalating costs made new reactor construction politically and economically unviable in many countries during that period (Eiser et al., 1990). Across much of the West, nuclear capacity remained essentially flat, as the technology became associated with catastrophe and institutional mismanagement. Despite the legacy of major accidents, sentiment within the nuclear industry today is overwhelmingly optimistic. Nuclear energy is regaining momentum because decarbonization policies require large-scale reductions in CO₂ emissions while meeting rapidly growing electricity demand. This convergence of pressures has led many to describe the current moment as a “nuclear renaissance.”

Although some countries implemented nuclear phase-outs after the Fukushima accident, many of these bans have since been reversed. As explored further in Chapter 4, nuclear energy's resurgence is tied to its ability to generate large amounts of electricity without releasing carbon dioxide, an increasingly critical metric in climate policy. This renewed global expansion is led by China. The country plans to add roughly 150 gigawatts of nuclear capacity, equivalent to about 150 reactors, over the next decade. China currently operates 58 reactors with another 31 under construction and will soon rival the United States, which maintains the world's largest fleet at 94 reactors (U.S. Energy Information Administration, 2024; World Nuclear Association, 2025c). Remarkably, China only began building nuclear power plants in the 1990s. Its rapid rise is attributed to fast approval timelines, favourable financing, strong public support, economies of scale, a robust domestic supply chain, and a streamlined regulatory environment (Wang & Lloyd, 2024). Following China's lead, both nations that have nuclear energy, or never built nuclear capacity at all, have aligned, and are now moving toward new reactor development.

Communicative and Cultural aspects of the Modern Nuclear Industry

Three Mile Island, Meltdowns and Risk Communication

One of the central discourses to emerge from nuclear accidents is that of catastrophe and exceptionalism, which is the idea that nuclear power is uniquely dangerous and therefore fundamentally untrustworthy. This discourse did not arise solely from meltdowns themselves, but was powerfully mediated through popular culture and mass media, which helped translate risk into emotionally resonant narratives. *The China Syndrome* (1979) was one of the first nuclear catastrophe films that is set through a dose of realism. What is especially coincidental, is

that the film was released 2 weeks before the TMI (Three Mile Island) meltdown. While individuals grappled with comprehending the events that occurred in Harrisburg, Pennsylvania, moviegoers were formulating their own understanding as to the demise of TMI. Wills (2006) contends that this led to a merging of fact and fiction, and in the subsequent coverage of TMI, news organizations would cross pollinate the imagery and narrative of the event and the film (p.111). TMI remains one of the most influential events in the history of nuclear energy discourse, notably through the buildup of environmental concern and the media coverage. On the post TMI media imagery, Historian Finis Dunaway (2015) writes,

“...even as they popularized antinuclear concern, these images also detached the accident from broader manifestations of energy crisis and focused public attention on the nuclear power plant as the sole locus of environmental danger” (p.132).

Reaching this conclusion is partially due to the sheer attention that was paid to TMI. The week after the accident, 40% of television evening news across America was dedicated to the meltdown. The Washington Post described TMI as a “red meat event,” a term used to describe a never-before-seen Journalism opportunity. The Philadelphia Journal ran the headline “nuclear terror,” the Daily News included an image of a scared Jane Fonda from *The China Syndrome* with the news that radiation had pierced four-foot walls. Walter Cronkite three nights after the initial meltdown claimed on the nightlight news that, “The world has never known a day quite like today. It faced the considerable uncertainties and dangers of the worst nuclear power plant accident of the atomic age. And the horror tonight is that it could get much worse” (Dunaway, 2015, p.132). The fear of radiation after TMI completely rerouted to powerplants, with Zaretsky (2018) noting that women and children especially were told to heed the warning of radiation poisoning, and to not be in the vicinity of nuclear energy production.



Figure 2.4. Demonstrators gather at the Pennsylvania State Capitol during an anti-nuclear rally in Harrisburg on September 4, 1979, following the Three Mile Island accident. *Photo credit: National Archives and Records Administration via Wikimedia Commons.*

TMI was an example of the hand-wringing that can happen around a nuclear event, in the case of Chernobyl and Fukushima, the post accident cultures of communication exemplify how secrecy and deception amplify fears. This culture is evident from the first nuclear accident at the Windscale nuclear plant in the United Kingdom, in 1957. Despite initial reports, recent revelations led to multiple scientists confessing that they needed to double their initial reports of radiation contamination, and discovering the impact of radiation on cancers was worse than initially thought (Mckie, 2007). What began at Windscale as selective disclosure would, at Chernobyl, become a fully institutionalized system of secrecy with global consequences. After much reflection, the general consensus in the nuclear science community is that the Soviets suffered from both their isolationist geopolitics, and their lack of transparency. In terms of transparency, Chernobyl reified fears around a central theme of nuclear politics; secrecy (Kinsella, 2005). Despite the Soviet policy of *Glasnost*, which was Gorbachev's promise of more openness within his government, the health impact and scale of radioactive material release due

to the explosions were largely kept secret (Shlyakhter & Wilson, 1992, p.25). The data which was forwarded up the chain, and what was ultimately disseminated, according to Yaroshinskaya (2011) was an incomplete picture of the action radiological damage that had occurred. The culture of secrecy surrounding the nuclear accident eroded public trust both in the soviet government, and nuclear energy (Plokhly, 2018).

Even after a moderate accident such as Three Mile Island, the culture of the nuclear industry rendered the post meltdown communication problematic. On the ground, U.S. nuclear regulators had radiation monitoring operational by 10 a.m., approximately six hours after the initial meltdown, and were recording only moderate radioactive releases. Despite this, the post meltdown plan made a serious mess, as evacuation communications were confusing, knowledge about damage to the reactor core was delayed, and mixed information was given to the hoards of media reporting on the incident (Martin, 1980). This led to a variety of different media reports. The three main television networks told different versions of TMI, with some more sensationalist than others, and attention was paid more to scenes of people fleeing the vicinity in lieu of mixed messaging from officials at the scene (Osif et al., 2004, pp.53-55). While Three Mile Island exposed the fragility of nuclear crisis communication, later accidents would unfold and amplify public scrutiny.

Fukushima represents a critical moment in the history of nuclear energy, where technological failure, institutional trust, and communication breakdown converged under unprecedented public scrutiny. Fukushima is the first nuclear meltdown in the social media era, and the Japanese public was incensed that much of the information about the meltdown and radiation flooded social media feeds via unofficial channels (Bricker & Nihon, 2014. p.203). The

erosion of trust between the government, TEPCO (Tokyo Electric Power Company), and the public was severe after Fukushima, and many scholars argue it boiled down to poor crisis communication (Elliot, 2013; Bricker & Nihon, 2014). Mixed messaging engulfed the hours after the accident as reports varied the next day from, “we are safe and lucky this time,” to “this could get real ugly” (Lochbaum et al., 2014, p.42). There were several issues building up to the meltdown, chief among which was the power of the nuclear industry over the regulators; what Kingston (2012) refers to as regulatory capture. The regulatory capture in Japan resulted in a culture of lax safety protocols and downplaying risks, which permeated through a “nuclear village” unconcerned with potential hazards such as seismic citing concerns (Kingston, 2012). It was even uncovered that Japanese authorities believed that the possibility of the backup power supply for the power plant failing was so remote that there was no need to consider scenarios in which this could happen (Lochbaum et al., 2014, p.19). Throughout the Fukushima crisis, contested definitions of radiation risk stoked a complete breakdown in trust between citizens, nuclear scientists, and government officials. Throughout the aftermath, officials were downplaying radiation exposure data, and withholding information of radiation clouds impacting further communities (Miyazawa, 2022, p.70). This motivated a crop of citizen scientists to begin a widespread open source radiation monitoring campaign, which was celebrated for its effort to thwart the status quo of the governance of risk and crises (Morillo, 2016). Beyond its regulatory and political consequences, Fukushima reaffirmed the extent to which nuclear risk was already mediated through culture, drawing on long-standing symbolic representations that shape how nuclear technology is imagined, remembered, and feared.

Nuclear Pastiche & The Simpsons

Following the Chernobyl disaster in 1986, civilian nuclear energy development across much of the world came to a standstill. While largely brought on through regulation and policy motivated by safety concerns, culture played an important role in the discourses which shaped the symbolism of nuclear energy in this era. Reading cultural texts alongside events and historical shifts in policy helps better understand how nuclear energy transitioned from an icon of modernist progress to a source of dread. One of the most influential vehicles for this transformation was the popular animated television show, *The Simpsons* (1989-). Throughout the series, the Springfield Nuclear Power Plant plays host to a series of motifs which dramatize the harmful effects of nuclear power.

These motifs follow Homer at work where he neglects safety precautions, and in one episode in the first seasons, Bart and his classmates visit the plant and observe common tropes popularized throughout the show: glowing waste, mutant fish, and bumbling technicians. The Simpsons is important because it acts as both a guide and a mirror to the cultural attitude surrounding nuclear energy at the time. These are aesthetic tropes, or what is referred to theoretically as pastiche; parody stripped of satire (Jameson, 1991, p.17). By reducing Nuclear energy to its risky tropes, the pastiche in the Simpsons reconfigures nuclear energy into empty symbols and repetitive patterns, undermining our ability to conceive of a practical future for the power source (p.43). In a similar vein, this could be seen as simulacra, which are flattened, commodified images that displace the complex, real-world history of nuclear technology with easily digestible icons of disaster, absurdity, and risk (Debord, 1995). In a sense then, pastiche in this era is a way of dealing with the trauma of nuclear disasters, while also driving the possibility of a true revival out of the question. *The Simpsons* is an important cultural marker of attitudes

toward post Chernobyl nuclear energy, and is recognized as such by the nuclear industry. For example, the US Department of Energy recently released a blog titled, “7 Things The Simpsons Got Wrong About Nuclear.” One bullet point reassured readers that fuel rods are in fact *not* used as paper weights (U.S. Department of Energy, Office of Nuclear Energy, 2025).

There are plenty of sources from the last 30 years which use nuclear pastiche as an aesthetic trope. Video games have played a central role in extending nuclear energy pastiche to younger generations. The *Call of Duty* franchise features maps like Nuketown and Pripjat, turning Cold War test sites and post-disaster zones into arenas of combat. Similarly, the *Fallout* series immerses players in a retro-futuristic post-apocalypse shaped by atomic catastrophe, offering radioactive ruins and mutant creatures as nostalgic entertainment. Beyond gaming, Chernobyl has been transformed into a setting for “dark tourism” and spectacle. Television shows like *Top Gear* and *River Monsters* have used the Chernobyl Exclusion Zone as a backdrop for adventure, exaggerating its dangers for dramatic effect. Ukrainian President Volodymyr Zelensky has even embraced this trend, framing Chernobyl as a destination for controlled “dark tourism” (Fedykovich, 2021). These cultural texts reveal how nuclear energy has been persistently reimagined not as a viable technological future, but as a recycled set of symbols, where risk, catastrophe, and apocalypse are endlessly reproduced, crowding out alternative imaginaries of nuclear possibilities.

The Modern Nuclear Industry & the Turn to Technology in Science and Technology Studies

Much of the sociology and philosophy of science and technology I’ve covered thus far, focuses primarily on moral/ethical, epistemological, and political questions on the role of science

and scientific discoveries. A key moment in the rise of STS and SSK (Sociology of Scientific Knowledge) throughout the 1970s is the turn to technology. In the turn to technology, science and technology studies scholars set out to answer fundamental questions about the role technology plays in society, and conceptualizations of technological determinism and social constructivism (Woolgar, 1991, p.30). Throughout this era of STS discovery, the base assumption is that technologies are not mere tools, but are either socially constructed entities or entities capable of having their own politics and agency.

Technological Determinism

Technological determinism frames technology as an inevitable, agentic force that structures society while obscuring the political, economic, and cultural decisions embedded in its design. One of the initial theorists to take up a deterministic view of technology is philosopher Jacques Ellul, who released his seminal book, *The Technological Society* in 1964. In this book Ellul claims that the way our society is oriented in modernity is around “the machine” and that “technique” is the way in which technology constructs society (p.5). It is thus humans who adapt to the machine, rather than the machine being constructed out of human will. With respect to the “turn to technology,” Ellul claims that we can no longer conceive of science without a technical outcome (p.8). This is due to a myriad of factors, most notably that the demands of capitalism mean that there is no interval between scientific discovery and technical application anymore. Ellul is simply illuminating the core of what determinism suggests - that if there is a technical application of a science (i.e. nuclear fission being applied as the atomic bomb), there is no agency for the scientist to stop this application - the technique will carry out the will of the machine (p.10). This argument is also made by Langdon Winner in his book *Autonomous Technology* (1977), when he claims that discovery in science seems to automatically mean a

technical application and technological progress (p.73). In other words, science is no longer an independent category of discovery, rather its value is in its technical applicability.

Other theorists view technology in a determinist light including Marshall McLuhan, who through his theory of “medium is the message,” (1964) used the framework of media to explain that communication technology shapes human perception. Lewis Mumford was perhaps the first to give power to determinist visions, as in *Technics and Civilizations* (1934) he contemplated how understanding the machine would aid in understanding society as a whole (Williams, 2002, p.141). Determinists tend to favour teleological arguments of technological development. By this I refer to the ways in which determinism is often accompanied by a chronology of inevitability, rather than a more organic approach to technological development, based on the specific cultural and social needs of certain groups in certain contexts. In this light technological determinism highlights how the material properties of nuclear energy drive its social, political and cultural outcomes, including risk.

Social Constructivism

The most effective way to explain the social construction of science and technology is to begin with this statement: “The treatment of scientific knowledge as a social construction implies that there is nothing epistemologically special about the nature of scientific knowledge: it is merely one in a whole series of knowledge cultures (Pinch & Bijker, 1984, p.401).” This idea built on the foundations laid by the sociology of scientific knowledge, laid out by David Bloor (1976;1991) who had a specific interest in epistemological interactions between sociology and science. Bloor contends that scientific knowledge is not just a pure natural phenomenon, rather it requires sociological explanation, such as the social norms which permeate experimentation, the

paradigm with which the scientist is working, professional interests, etc., (p.7). Applied to technology, Pinch & Bijker reject the idea that contemporary scientific knowledge is valuable only in its technological application, rather they claim that technology is also socially produced in various social contexts (Pinch & Bijker, 1984, p.403). The linear relationship between initial study to technological application argued in different ways by technological determinists does not reflect a more complex history of technological development. A multi-directional model of technological development accounts for the variants of a technology which die or survive, often at the hands of the social groups which utilizes such technologies (p.414). Broadly speaking, with respect to technological development, a social constructivist may ask how labour relations, policy developments, individual goals, social groups or cultural differences impact the development and implication of certain technologies.

Examples of this with respect to nuclear energy is Gabriel Hecht's book, *The Radiance of France: Nuclear Power and National Identity after World War II* (2009). The French nuclear programme was not simply a result of the viability of nuclear energy, but rather part of a nation-building political agenda. Throughout the book, Hecht finds that nuclear energy as a political project ran much deeper than public discourse, it permeated throughout the engineering processes and was interwoven with technological development; this is what Hecht describes as technopolitics. This, along with other state led efforts, from centralizing construction and regulation, is a microcosm of why France's centralized nuclear mandate was so successful, not necessarily the advancements and viability of nuclear power. Social constructivism emphasizes how nuclear energy is shaped by politics, culture, and discourse and how nuclear energy risk is constructed, communicated. Simply put, it is important to be critical of works that posit

nuclear technology as a given, and instead approach the subject through how it is constructed, experienced, celebrated and opposed (Irwin, 2000, p.85).

Co-Constitutive Approaches

Co-constitutive theories of technology reject technological determinism in favour of a relational understanding of how humans, technologies, and social contexts mutually shape one another. Actor-Network Theory (ANT), developed by scholars such as Latour, Callon and Law, conceptualizes this relationship as a heterogeneous network composed of both human and non-human actants (Callon 1987; Latour, 1987; Law, 1992). Within this framework, technologies do not possess agency independently, nor are they mere tools of human intention; rather, agency emerges through networks of materials, institutions, expertise, cultural meaning, and political arrangements. Langdon Winner's work moves in a similar direction. While *Autonomous Technology* (1977) presents more of a determinist argument, Langdon Winner began writing in more of a co-constitutive tone beginning with his 1980 article, *Do Artifacts Have Politics?* This article explains the human-technology-context tryptic through his explanation of a program. A central claim of Winner's article is that technical things have a set of politics. While this sounds determinist, these politics need the correct context and human interaction to have any agency.

The co-constitutive model of technology offers the most robust framework for understanding the relationship between society and complex technological systems, particularly nuclear reactors. Rather than treating technology as either a neutral tool shaped solely by human intent or an autonomous force that determines social outcomes, co-constitution emphasizes the mutual production of social order and technical form. In *The Whale and the Reactor* (1986), Langdon Winner argues that technologies are not passive entities, but rather have the ability to reshape human activity. The result of this is a mutually constitutive relationship whereby we use,

improve and tinker with technologies, which then in turn impact our behaviour, redefine our habits, and on a broader level is “world-making” (Pp. 10-16). Applied to nuclear energy, this insight is especially salient. Nuclear reactors exemplify what Winner terms “inherently political” technologies, not because political values are merely projected onto them, but because their material properties necessitate specific forms of governance.(p.32) Seen through a co-constitutive lens, the nuclear reactor is therefore not a singular object but an assemblage of hardware, expertise, institutions, safety cultures, political regimes, and imaginaries of risk and progress, which are continuously negotiated.

More modern co-constitutive descriptions of technology see the ways in which a technology can create and be used to inform cultural identities. For example, as the energy transition ramps up and nations unravel policy to promote the shift to cleaner energy sources, Jasanoff and Kim (2013) argue that the energy transition is not simply swapping “dirty” resources for cleaner ones. It is restructuring cultural and social infrastructure to adhere to a specific sociotechnical imaginary. Sociotechnical imaginaries, according to Jasanoff & Kim are, “collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects” (Jasanoff and Kim, 2009, p. 120). The context has evolved to the point where nuclear energy is no longer simply framed in authoritarian terms. In a contemporary context shaped by decarbonization, nuclear energy’s agency is increasingly reconstituted around its low-carbon credentials, demonstrating how risk isn’t a static category, but part of the broader assemblage of nuclear technology, politics, and society. While some may contend that Jasanoff & Kim are constructivist scholars, the basis of their theory is

that societies and technologies are mutually produced through institutions, norms, visions of the future, and technological systems, lending to a more co-constitutive framework.

Conclusion

This chapter has traced the evolution of civilian nuclear energy from the immediate aftermath of World War II to the present, demonstrating that nuclear power is continually shaped by political, cultural, and environmental regimes of risk governance. From Atoms for Peace to contemporary decarbonization policies, nuclear energy has been repeatedly rearticulated as a technology of progress, only to be destabilized by the material realities of accidents, contamination, and institutional failure. What emerges across this history is not a linear trajectory of technological maturation, but a series of contested moments in which nuclear energy's legitimacy is renegotiated. In the next chapter, I take the critical historical conjunctions which produce the discourses surrounding nuclear energy and evaluate them in terms of risk. Risk, while not explicit, was a central theme throughout the first two chapters. This chapter for example has shown how early techno-utopian visions attempted to sever nuclear power from its military origins, primarily to reframe the atoms relationship to risk. Nuclear weapons testing, reactor accidents, and secrecy repeatedly re-anchored civilian nuclear power to catastrophic possibility. The rise of environmentalism in the 1960s and 1970s further reframed nuclear energy as one among many industrial threats to ecology.

By integrating perspectives from science and technology studies, this chapter has emphasized that nuclear energy cannot be understood through deterministic or purely constructivist explanations alone. Technological determinism highlights the material constraints and political structures imposed by nuclear systems, while social constructivism reveals how national identity, policy, and discourse shape nuclear development. Co-constitutive approaches

offer a more comprehensive lens, as nuclear reactors emerge not as isolated artifacts, but as stabilized socio-technical networks that require specific forms of authority, expertise, and trust to function. Their risks then are intrinsic to the configurations that produce nuclear energy in the first place, an idea explored in chapter three through an evaluation of manufactured risks. Risk is complex, and throughout this chapter, it is mediated both through nuclear accidents and cultural texts, such as cold war educational films to post-Chernobyl pastiche in *The Simpsons*. These cultural framings persist alongside policy debates and technical assessments, making nuclear energy's history a fascinating exercise in the co-evolution of technological, communicative, and cultural realities.

Chapter 3

Nuclear Energy & Risk: 3 key Areas

Introduction

The critical conjunctions of nuclear energy history traced in Chapters 1 and 2, demonstrate that since its inception, the energy source both constitutes and is constituted by cultural anxieties, political movements, and evolving scientific discovery. From the earliest experiments with radioactivity to the development of civilian nuclear reactors, narratives of danger, uncertainty, and control have shaped how societies interpret the risk of nuclear energy. This chapter examines how risk, in its environmental, health-related, and political-economic dimensions, became the dominant framework through which nuclear energy is understood and rationalized. This chapter therefore examines three interconnected domains where nuclear energy risk materializes. The first is *environmental risk*, shaped by weapons testing, reactor meltdowns, and the long-lived presence of radionuclides in ecosystems. The second is *health risk*, revealed through both catastrophic exposure events and institutional negligence that foreground the invisibility of radiation and the reliance on dubious expert interpretation. The third is *political-economic risk*, which emerges from the financial, regulatory, and infrastructural burdens that accompany nuclear energy development, burdens which continually reshape national energy policies. These risk areas are broken down into events (the critical moments in which the risk of nuclear energy with respect to the environment, health and political economy became apparent), and risk outcomes (the risk theories which apply to the events that in turn create out risk perceptions). This chapter is structured this way to show how nuclear energy is both constitutive of and constituted by risk discourses.

The risk perceptions of nuclear energy that emerge across environmental, health, and political-economic domains are not linear, but are shaped by overlapping interpretations of nuclear events. The following sections examine environmental, health, and political-economic risk as analytically distinct but mutually reinforcing dimensions through which nuclear energy is perceived. Briefly explored in Chapter 2, the overall concern among environmentalists with regard to nuclear energy was the broader pattern of the disconnect between nature and culture. In risk discourse, this manifests as a manufactured–natural binary, in which man-made hazards are perceived as more threatening than risks framed as natural or beyond human control. In terms of health, radiation is the key factor in the risk perception of nuclear energy, namely that it is invisible and toxic. Invisibility heightens risk perceptions by increasing reliance on expert mediation; experts whose credibility is questioned with each poor response to nuclear accidents. Toxicity further amplifies this effect, as toxins and contaminants sit at the centre of radiophobia-driven risk discourses.

One of the goals of this chapter is to bring political and economic risk into a discussion with environmental and health risks, as nuclear energy discourses tend to keep the interlinked categories separate (Kinsella et al., 2013, p.280). Where risk is identified, regulation follows, and in the case of nuclear energy this regulatory politics has economic, environmental, and public health consequences. In the realm of political economic risk, the regulatory burdens and cost overruns associated with nuclear energy introduces an assumption that the political and economic risks are systemic to the nuclear energy industry. This creates a chicken and egg situation whereby regulation is put in place to make sure nuclear energy projects adhere to safety standards, yet those same regulations make investing and building out nuclear prohibitive. In

exploring these risk themes, this chapter offers the discursive backdrop to the continued debate over new nuclear development, one rife with questions about construction costs, risks of severe accidents, nuclear waste, and carbon emissions (Sovacool, 2010, p.120)

1. Nuclear Energy and Environmental Risk

The environmental consequences of nuclear energy extend beyond the controlled boundaries of laboratories, test sites, or power plants. From atmospheric weapons testing to reactor accidents, nuclear activities have repeatedly demonstrated that radiation moves through ecosystems in ways that challenge assumptions of control and containment, as evidenced from contaminated milk supplies in the United States (Commoner, 1959) to Chernobyl's impacts on reindeer in Scandinavia (Strand, 1994). This section traces how both weapons tests and reactor accidents have impacted the environment and, in turn, public perceptions of nuclear risk. What is ultimately uncovered is that the expansion of nuclear capabilities, both militarily and not, produced the complexity and danger it aimed to mitigate against (Beck, 1992). These events helped crystallize a broader shift in how environmental risk is understood as a consequence of technological intervention. As a result, environmental concern surrounding nuclear energy is shaped less by immediate ecological damage alone than by the recognition that once radiation enters natural systems, it fundamentally alters the relationship between nature and culture. This section examines how nuclear weapons testing and reactor accidents have contributed to environmental harm while simultaneously reshaping public perceptions of risk, laying the groundwork for enduring anxieties rooted in the binary between natural and manufactured risks.

Events - Radiological Impact on the Environment

Bomb Testing

The environmental impact of nuclear weapons testing has left a devastating legacy, from underground, above ground, and atmospheric tests. Throughout the 1940s and 50s, little was known about the environmental toll radioactive fallout would have, and the assumption was that if a test is isolated geographically, or atmospherically, its impact would be minimal. Beginning in the late 1950s however, details began to emerge of the environmental legacy of nuclear weapons testing. For example, Biologist Barry Commoner detailed finding the radioisotope Strontium-90 in American children's teeth. The culprit was high levels of radiation in the milk children were drinking due to atmospheric fallout affecting dairy cows (Commoner, 1959). Because roughly 70 percent of Earth's surface is covered by water, significant quantities of radiation released into the atmosphere during weapons testing are often deposited into the world's oceans. For example, high levels of the radioactive isotope carbon-14 can be found in the marine life of the North Atlantic, as the gasses from the ocean and atmosphere constantly interact (Pravalie, 2013). In the Pacific Ocean, the legacy of nuclear weapons testing extends to the deepest ocean trenches; one study detected elevated levels of carbon-14 in crustaceans inhabiting even the most remote regions of the planet (Wang et al., 2019). The persistence of radioactive isotopes across oceans, food systems, and remote ecosystems reveals a fundamental misconception underlying early testing practices: radiation, once released, cannot be reliably contained.

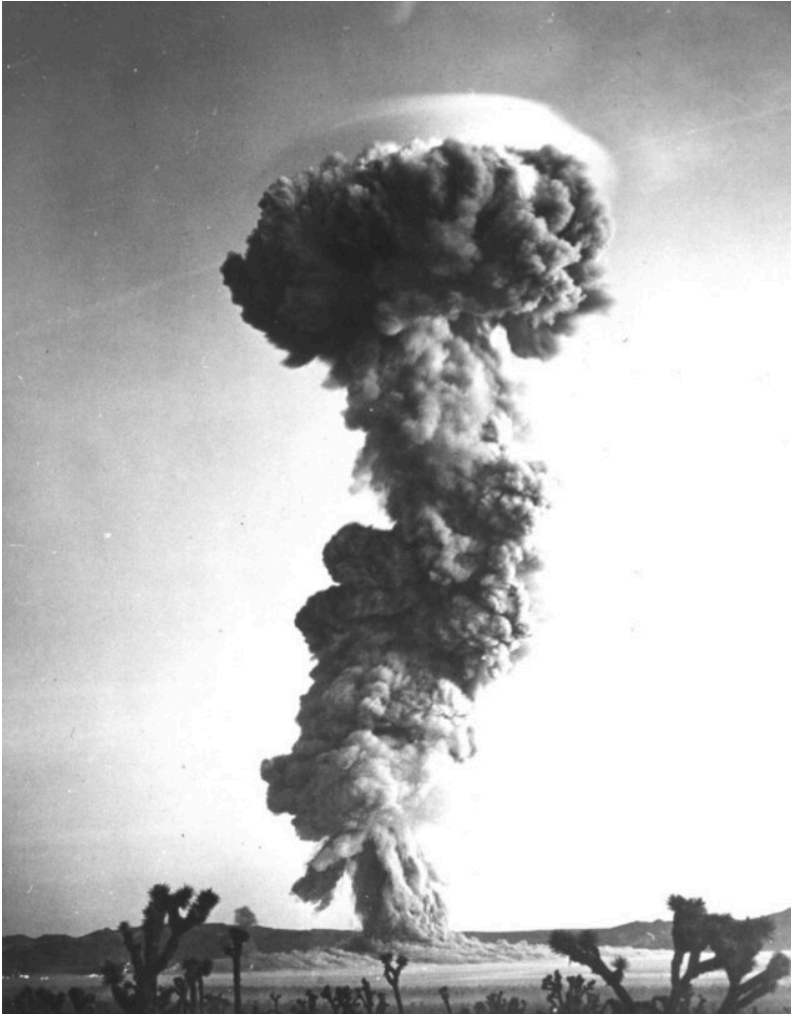


Figure 3.1. *A mushroom cloud emerges from the Nevada desert.* Source: Federal Government of the United States (1953), public domain via Wikimedia Commons

This is the case with underground weapons testing as well. In 1963, revelations about the impacts of above-ground weapons testing led to a partial test ban that pushed nuclear tests underground, under the assumption that radioisotopes could be more easily contained, which was an assumption that proved incorrect. The most notorious location for underground nuclear weapons testing, the Nevada test site, witnessed 100 above ground tests and 828 underground tests over its lifetime (Department of energy, 1994). As a result there are excess levels of plutonium in the surrounding soil (Turner et al., 2003). The Nevada test site, thought to be

shielded away enough to avoid meaningful nuclear contamination, had a profound effect on local agriculture. In 1953, a series of weapons tests left Utah farmers in turmoil, as it was uncovered through a 1956 lawsuit that Iodine-131 caused a high rate of lambing ewes and new lambs to die or be stillborn (Meyers, 2019, p.252). At the Nevada test site, radiation leaks were common, and led to the release of the radioisotope Iodine-131 during the Baneberry underground nuclear test on December 18, 1970, impacting local seedling development and reproduction (Park & Ewing, 2024). In that same paper, it was determined that underground testing was vulnerable to ground water flow exacerbating the spread of radioisotopes.

The abuse of the environment in the name of nuclear weapons development was largely kept secret until the 1990s when the Clinton administration uncovered the full scale of nuclear activities and research in an effort for transparency. One of the official descriptions was that the environments which experience high rates of radiological impact were “national sacrifice zones,” areas which bore the brunt of nuclear testing to realize the dreams of atomic weapons (Davis, 1993). These sacrifice zones now extend to regions that have experienced nuclear meltdowns; however, in place of nuclear weapons lies the ambition of achieving widespread civilian nuclear energy production. Such accidents generate heightened radiation levels and enduring nuclear stigma.

Meltdowns

When nuclear meltdowns occur, a wave of radionuclides is released into the atmosphere, biosphere, hydrosphere and pedosphere, which means that radiation levels increase in the water, air and soil both in the vicinity of a powerplant, and as far as the radioactive clouds will take them. Chernobyl’s legacy of environmental harm is evident both in the exclusion zone that

surrounds the power plant, and the impact felt across Europe. For example, the Sami people span northern Scandinavia, where reindeer husbandry is a key industry and food source. After Chernobyl, wind and rain carried a radioactive cloud over the forests where reindeer graze. As a result, the mushrooms and lichen they feed on became contaminated, and the reindeer themselves absorbed the radiation (Strand, 1994). The Caesium-137 present in the reindeer has a half life of 30 years, and is still impacting the food security of the Sami people 40 years later (Minagawa, 2021). This is not a unique situation as several studies reveal a high concentration of Caesium-137 in the environment due to the Chernobyl cloud, such as in the mushrooms in the Czech Bohemian Forest (Cadova et al., 2017), and lichen and moss in Romania (Cosma, 2002). After Fukushima, radiation levels increased in San Francisco after a radioactive cloud carried rainfall to the area (Steinhauser et al., 2014). Beyond a direct environmental impact, the areas surrounding the site of a nuclear meltdown incur stigma that has a lasting effect. This lingering stigma often resurfaces whenever new actions are taken at affected sites, even long after radiological conditions have stabilized.

For example, in 2023, Japanese officials released treated water from the Fukushima power plant back into the ocean, after radiation returned to safe levels. Claims from Japanese radiation officials did not stop the Chinese Government from decreeing an outright ban on Japanese seafood imports. In a show of support, the American ambassador to Japan, Rahm Emmanuel, ate seafood from the part of the ocean where the Fukushima wastewater was reintroduced (Hoskins, 2023). Despite this action, the ban remains, and the end result is a devaluation in the seafood from the Fukushima region, and a hit to the cultural reputation of Japan as an exporter of high quality seafood (Wakamatsu & Miyata, 2017). Taken together, these

examples reveal how risk perceptions become heightened when a natural environment is contaminated by a human-made radiological source. After TMI, the media reports of radiation piercing the walls of the reactor were ubiquitous, however, environmental scans of the local area revealed no heightened levels of radiation in the local river, fish, dairy cows, deer, and soil (Osif et al., 2004, pp.73-75). The resulting concern is rooted less in the actual dose levels than in the sense that once nature is tainted, it becomes fundamentally irredeemable. This risk perception is explained through the manufactured vs natural risk binary explored in the risk outcomes of radiological impacts on the environment.

Risk Outcomes

Manufactured vs Natural Risk

In the 1970s, opponents of nuclear power deliberately avoided linking their cause to nuclear disarmament, worried that such an association could weaken their movement. Instead, they focused on framing radiation as an environmental threat (Lynch, 2012). At the same time, environmentalists, who had originally been more concerned about the impacts of fossil fuels, began to shift their attention toward nuclear issues. As resistance to nuclear reactors grew, the connection between the two movements strengthened, to the point where some antinuclear activists started to view themselves as environmentalists first and foremost (Lynch, 2012, p.335). The risk from nuclear weapons to power plants was part of a broader societal and philosophical shift toward the protection of nature. Even with civil defense dissipating and fallout preoccupying much less cultural concern, nuclear energy reactors endured the label of a manufactured, destructive stain on an otherwise natural landscape (Perrine, 1998; Halden, 2017). The segmenting between nuclear energy as an achievement of technology, balanced against the

backdrop of nature is long a theme in theoretical writing on nuclear energy and environmental discourses. As Winner observed, the juxtaposition of the whale and the reactor at Diablo Canyon represented two distinct symbols of power, nature and human technology. The whale, moving gracefully within an ancient ecosystem, evoked a vision of the world as it had long existed, whereas the reactor, an immense technological structure driven by human intent, illustrated the world as it was quickly becoming (Winner, 1989, p.168). In this vein, nuclear energy, more than any other power source, stands as the antithesis to nature, embodying the deep ambition of technological society devoid of environmental consideration. As our dependence on increasingly complex systems deepens, so too does our exposure to the novel risks they create. These vulnerabilities emerge not from nature itself, but from the very technologies designed to control it (Winner, 2004, p.155).

The discourses that emerged around early nuclear weapons testing and their environmental effects crystallized anxieties that nuclear energy was not merely dangerous, but fundamentally disruptive to the natural order. Popular and scientific rhetoric alike speculated that thermonuclear weapons could melt the Arctic ice cap, trigger earthquakes, or even alter global weather patterns, reflecting a profound uncertainty about humanity's newfound ability to disrupt planetary scales. As Weart (2012) argues, such fears were less about specific empirical outcomes than about what nuclear energy symbolized: a force perceived to exceed natural limits and violate the presumed stability of the Earth itself (p. 99). Within this framing, nuclear energy comes to embody manufactured risk in its most extreme form, a wholly human creation untethered from natural processes and symbolically positioned as nature's antithesis. Nuclear power thus emerges as a product of a technoscientific order that produces novel, systemic, and irreducibly manmade risks, a hallmark of what Beck (1992) identifies as the risk society.

One of the main risk outcomes that is amplified through the environmental fallout of nuclear energy, and the imposition of high technology on society, is natural vs manufactured risks. Risk scholars Mary Douglas and Aaron Wildavsky illustrate this binary in their seminal book *Risk and Culture* (1982), where she explores the cultural values which shape risk perception. They argue that technology, especially high technology, has changed our perception of risk, wherein we have a cultural expectation that technology should be advanced enough to prevent accidents (p.32). This perception is deceptive, as increasing technological complexity multiplies points of failure and heightens the inevitability of accidents (Perrow, 1984, p.7). Juxtaposed with more primitive versions of society, risk was much more of an exercise in fate rather than statistical probability. Fate has given way to a prediction mechanism of trivial failure, wherein technology becomes a statistic of accident rate (p.43). The manufactured risk of nuclear energy is illustrated by Rachel Carson who writes, “Radiation is no longer merely the background radiation of rock, the bombardment of cosmic rays, the ultraviolet of the sun that have existed before there was any life on earth; radiation is now the unnatural creation of man’s tampering with the atom (Carson, 1962, p.7). In this sense, technology is the “manufactured” in the natural–manufactured binary. It is an intervention that not only departs from nature but generates entirely new domains of vulnerability and risks that did not exist prior to its introduction.

This is the “fatalism” of progress, the idea that the management of these risks isn’t a choice, and that we are imprisoned by modernity and pragmatism (Beck, 1995, p.58). Here, fatalism is organizational, embedded in the very processes through which risks are assessed and managed. Drawing on this insight, perceptions of risk surrounding nuclear reactors are informed

not only by past accidents, but equally by the technopolitical structures through which they are managed. What is revealed among all nuclear accidents inevitably is a combination of negligence, technical failure, and institutional mismanagement. For example, the revelations uncovered after Fukushima were a host of nuclear management issues, from the reactor design, to political and industrial failures (Elliot, 2013). The perception of risk however, differs whether these technologies seem natural or manufactured. This distinction becomes particularly salient when examining energy production, where perceptions of risk are filtered not just through historical experience and technopolitical management, but amplified whether the technology is seen as an extension of nature or a departure from it. There is nothing seemingly artificial or manufactured about taking a piece of coal out of the ground and burning it. Like nuclear energy, this process is meant to create heat which spins a turbine and creates steam, however the means in which we reach the end are different. The imagery and iconography surrounding coal versus nuclear energy sharply reinforce the manufactured/natural divide. Coal is associated with blue collar labour in scenic locales such as the Blue Ridge Mountains. It is framed through imagery of honest work and the bolstering of community economies, and is embedded with discourses of masculinity (Gildart et al., 2024) and working class nostalgia (Strangleman, 2013). Nuclear on the other hand is embedded with discourses of the mad scientist/sorcerer (Weart, 1991), specialized knowledge, and secrecy (Kinsella, 2005).

Beyond shaping public perceptions of risk, this manufactured framing of nuclear energy also transforms how environments are organized, inhabited, and valued. Anthropologist Joseph Masco notes that before the Manhattan Project, Los Alamos was a place managed through the localized knowledge of the Pueblo people. The Manhattan Project replaced the ecological and

natural “place-making” of the Pueblos with manufactured destruction (Masco, 2013, pp.103).

Los Alamos National Laboratory is still operating, having permanently altered the environment and displacing the indigenous epistemologies which governed the landscape. Nuclear energy through its material scale remakes the environment according to its logic. It is because of this, along with the risk perception of radiation, that the environmental impact of nuclear energy is so great. Ultimately, what emerges is not simply a debate over technical hazards but a broader cultural narrative about how societies interpret interventions into nature. Nuclear energy carries the weight of manufactured risk, amplified by its history, its ecological placemaking and its entanglement with high-modernist ambition and hubris. As a result, opposition to nuclear power is both about its material dangers and what it symbolizes, which is an uneasy fusion of technological power and the vulnerabilities it creates.

Toxicity Discourses of Manufactured Contamination

In relation to the stigma which envelopes an area after a nuclear event, the sensitivity toward radiation beyond health measures reflects a fear of environmental contamination. In terms of health, toxicity discourses persist through cultural means, however in terms of the environment, contamination is the central pillar through which toxicity is reified (Goldstein, 2017). In the 1970s, images of environmentalism were often not grounded in a virginal aesthetic of naturalness, rather contamination and pollution dominated visual discourses. Dunaway (2015) charts gas masks as a ubiquitous cultural image which created a material representation of the dangers of contamination. General air pollution, whether from radiation or other sources, was the main concern at the time, and the gas mask represented a protest to the degradation of the local environment, and the right to live in a clean environment (p.51). Furthermore, the gas mask symbolized the universality of toxic risk (p.52). Environmentalists at the time demonstrated that

there was no setting in which the world was not engulfed with man made pollutants and toxins. Part of what environmentalists were signalling was the globalization of risks, and the realization that the environmental contamination wasn't specific to locales.

Ulrich Beck explains that the globalization of risk is a hallmark of modern culture. Discourses of contamination and the imagery of the gas mask are not claims that certain industries present danger, rather that risk is inherent in the conditions of modernity. As Beck (2009) aptly puts it, the biggest opponent to the nuclear industry, is the industry itself (p.43). A function of manufactured risk, is the business and politics of now dealing or mitigating against those manufactured risks (p.50). If modernity was situated around the preservation of nature, environmentalists would don flower crowns. Instead, the production of manufactured risks being a hallmark of modernity reveals that wearing gas masks as protest, is the aesthetic resistance to manufactured contamination being embedded into society. In this context, nuclear environmental risk is perceived less through discrete measurements of harm than through the enduring fear of contamination as a condition of modern life. Radiation, as a pollutant, becomes the emblem of manufactured environmental risk, one that crystallizes broader anxieties about humanity's capacity to control the technopolitical systems it has created.

2. Nuclear Energy and Health Risk

Radiological accidents and experiments are often framed through technical failure, dose metrics, or epidemiological outcomes. Yet their most enduring impacts frequently emerge not from immediate physical harm alone, but from the social, ethical, and communicative conditions through which radiation exposure is discovered, interpreted, and governed. Because radiation is

invisible, and temporally uncertain, encounters with it place high levels of weight on institutions and experts. When those systems fail, through negligence or secrecy, the health consequences of radiation extend well beyond biological exposure to encompass risk perceptions such as stigma, mistrust, and fear. Scholars of risk studies have long argued that radiological harm cannot be separated from its social mediation. As explored in this section, radiological events become moments where radiation produces differing cultural anxieties about invisibility and toxicity. The following cases, the 1987 Goiânia accident in Brazil and the UK Medical Research Council's "radioactive chapati" experiments, illustrate how failures of communication, consent, and oversight transform radiological exposure into broader crises of public health and trust.

Events - Radiological Impact on Health

Goiânia Accident

In September of 1987, scavengers on the hunt for scrap metal explored an abandoned clinic in Goiânia, Brazil. They found a steel container, which unbeknownst to them contained radioactive materials meant for radiation treatment. The radioactive material was cesium-137, an isotope which emitted a strong blue light, a quality which unfortunately attracted the intrigue of local citizens. The men who recovered the steel container survived but suffered severe skin burns and nausea, with one of them eventually needing an arm amputation. Without knowing the source of their injuries, the men sold the container to a local scrapyard, where the owner's brother decided to take some cesium-137 home to show off of its light emitting qualities. His daughter died after playing with the foreign substance, alongside three others: two scrapyard employees and the scrapyard owner's wife, who brought the cesium to the authorities after suspecting it was dangerous (*Encyclopedia Britannica*, n.d.). The overall public health impact was immense. The local football stadium was converted to a triage center where over a 100,000

residents were tested for radioactive contamination. Of the 100,000, 249 residents showed signs of contamination, and 49 required medical treatment (Olivera et al., 2001). The waste from the incident, such as the houses and cars which exposed citizens lived in and drove, filled ten shipping containers, 3800 industrial drums and 1400 metal boxes. These receptacles were placed in two specialty tanks and buried underground (Clemons & Blumenberg, 2023, p.556).



Figure 3.2. *The radioactive source from the Goiânia Accident.* Source: IAEA Imagebank, public domain via Wikimedia Commons.

A follow up report by the IAEA (International Atomic Energy Agency) deemed that the nuclear regulatory authority in Brazil was liable for the radioactive container left behind in the abandoned hospital, and pointed to a complete lack of checks and balances between the nuclear authorities to account for the container (International Atomic Energy Agency, 1988, Pp.87-89). Most of all, communications was the main issue, with the CNEN (Brazilian National Energy Commission) not even knowing of the incident for a full 15 days. When the container was discovered, communication channels weren't leveraged properly, as radio and television stations

accidentally referred to the cesium container as a cesium bomb, inadvertently stigmatizing the residents of the city as irradiated (Svendsen et al., 2016, p.351). This issue reflects a broader pattern of communication failures during radiological accidents, which helps explain why radioactive health risks generate heightened fear and mistrust toward the authorities responsible for managing radioactive materials. The Goiânia accident fell victim to the social amplification of risk, which claims that the physical impact of an event doesn't determine the scale of its risk perception, rather the amplification or diminishment by social actors does (Kasperson et al., 1988). The secondary consequences of the accident, due to the risk amplification, were especially impactful. The fear of radiological contamination, even in places with the absence of exposure, triggered mass voluntary screening, prolonged economic disruption, widespread social exclusion of residents, and political mobilization against nuclear energy institutions across Brazil (Kasperson et al., 2001).

Radioactive Chapati

In 1969, the UK Medical Research Council (MRC) conducted a study in which they exposed 21 women unknowingly to radiation, justified under the pretext as an experiment to combat widespread anaemia in the South Asian community. The 21 women were asked to participate in a monitored dietary study, and were fed Chapati (an Indian style bread) dosed with Iron-59, a radioactive isotope, in the form of an "iron salt." The scientists in charge of the experiment worked out that the worst case scenario risk of the experiment was accidentally giving one of the women fatal cancer, which they worked out to a 35 in 1,000,000 chance (Medical Research Council, 1998, p.31). The women consumed one radioactive chapati every morning for four consecutive days, with scientists noting no real change in the women's underlying health. This experiment remained secret until filmmaker John Brownlow detailed the

MRC's true intentions in his film, *Deadly Experiments* (1995). In the film, the tactics used to get the women to participate in the experiment seemed especially vile. For example, in the case of a woman named Pritam Kaur, she went to her GP complaining about migraines. Her doctor told her it's probably anaemia, and much to her surprise prescribes her "specially prepared Chapati." In the following days, someone from the Medical Research council came to her house in the morning to deliver a Chapati, and always followed up with a call in the afternoon to make sure Pritam had eaten it. After a few days, a van picked up Pritam and other women who were part of the experiment, and took them to an Atomic Energy research building where the women's radiation levels were measured (Brownlow, 1995).

A follow up inquiry of this experiment in 1998 uncovered obvious ethical and medical concerns, prompting the MRC to note the ethical progress they had made since the study took place. While the 1998 inquiry uncovered the potential harm medical experiments can cause without participant consent, the rationalisation of this study lies in medical and scientific literary devices which boil radio-science down to diminutive rhetorical quantifications. This is revealed in the film, when a spokesperson for the MRC admits that it is unethical if the researchers never acquired consent, however, if the radioactive dose is "no greater than the standard," then an investigation is unwarranted. The MRC even went as far to say that the language barrier and use of a translator was a factor in the effectiveness of communications, as South Asian languages may be technically primitive and not even have the word for "radiation" (Medical Research Council, 1998, p.32). This of course ignores the reality that the MRC had no intention of explaining the radiation risk to the women. Notwithstanding the racial and gendered issues with the experiment, the lack of consent, and the potential radiation exposure of these women, the MRC's explanation of unwarranted communications should safe levels be observed is all too

familiar a play in the risk communication of nuclear authorities, and serves the ensuing risk outcomes in the relationship between radiation and health.

Risk Outcomes

Invisibility

The invisible nature of radiation presents two strains of risk perception outcomes. The first is that the invisible nature of radiation in itself creates fear. The second is that the invisible nature of radiation means that individuals have to put a mass amount of trust in experts, whether a radiological event is moderate or a catastrophe. If we begin with invisibility, radiation is particularly anxiety provoking because it is enigmatic. We cannot see it, it lasts forever, and the sickness is so variable, from nausea to death. Beck famously asks in his book, *World at Risk* (2009), “what if radioactivity itched?” His point is that risk only becomes socially recognisable when it is sensorially evident; without this, it must be interpreted rather than experienced. The invisibility of radiation contradicts human survival instincts, which rely on sensing and avoiding danger.

The perceptive experience of the invisible nature of radiation is what Anthropologist Joseph Masco refers to as the nuclear uncanny. He writes that the invisible and life threatening nature of radiation manifests in the nuclear uncanny which, “exists in the material effects, psychic tension, and sensory confusion produced by nuclear weapons and radioactive materials” (Masco, 2013, p.29). Masco focuses on the specific phenomena, whereby the temporality of invisibility is often what invokes the most fear. In her book, *Radiation Nation: Three Mile Island and the Political Transformation of the 1970s* (2018), Natasha Zaretsky explores what she refers

to as a crisis of visibility after the TMI accident. The initial part of the crisis is the invisibility of prescient information directly after the accident, and the second was that radiation eluded sensory perception (p.73). This is especially scary, and impacts the psychological inasmuch as the physical. Multiple studies conclude that mental rather than physical health is most affected after a nuclear accident, as the inability to detect long-term health effects often leads to sustained psychological stress, including anxiety, depression, and PTSD (Bromet, 2014; Shigemura et al., 2020; Wilson et al., 2023). Multiple studies after TMI conclude that there were elevated stress levels following the meltdown (Osif et al., 2004). Contrarily, it is hard to trace the physical health impact of invisible harms, as they often surface in the future. For example, after Chernobyl, the true health impacts of radiation exposure have emerged only over time, as researchers continue to uncover evidence of shortened lifespans (Gray, 2019). The lived experience of this is waiting for the invisible to render itself visible in the form of radiation sickness.

The one way to break this temporal risk perception is to measure radiation levels. Radiation becomes knowable only through technological mediation, often at the hands of an expert. If we take both examples, the Goiânia incident and the radioactive chapati, the invisibility of harm meant individuals did not know that they were exposed to radiation, and in both cases, experts were either negligent or transgressive. In Palmlund's (1992) evaluation of the six different roles in the social evaluation of risk, the *risk researchers* are intended to be the scientists and publicly funded aides who gather evidence and deem the acceptability of a specific risk. If risk researchers don't execute to a sufficient level, they become part of the risk generator class, and lose credibility among the public, as exemplified by Wynne's (1989) research on

radiological detection among UK Sheepfarmers after chernobyl. This is often the experience after nuclear meltdowns, as Miyazawa (2022), argues that the post-Fukushima failure to provide solutions by experts is tantamount to being part of the catastrophe (p.64). Materially, risk assessment post-meltdown is critical. If the radiation impact is underestimated, you could be putting many people in harm's way, and if it's overestimated, you run the risk of using valuable resources to remove people from harm's way, which in turn creates its own risks (Lochbaum, 2014, p.142).

Taken together, the invisibility of radiation not only renders risk imperceptible and therefore reliant on expert mediation, but it is also involuntary hazard, amplifying public unease and redirecting concern from the substance to the systems tasked with containing it. Involuntary is a key word, as it underscores another risk binary which amplifies the risk perception of radiation. Imposed versus voluntary risks form a binary: humans tolerate far higher levels of voluntary risk (smoking, drinking, riding a motorcycle) than risks imposed upon them (involuntary exposure to harm) (Starr, 1969). If a risk is involuntary, humans put a great deal of trust in “experts” to keep any hazards away (Slovic, 1988). Even more troubling is that expert perceptions can vary differently from lay perceptions. In a 1987 (1 year post-chernobyl) study of risk perception of nuclear energy in the U.S., the results yielded that 98.4% of nuclear experts deemed nuclear power safe, compared to just 6.4% of public interest individuals (Rothman & Lichter, 1987). Complete trust must be placed in the hands of experts, experts partially responsible for a host of accidents throughout the second half of the 20th century. It is precisely this reliance on expert management of an involuntary and imperceptible hazard that shifts concern from the substance itself to the institutions governing it, setting the stage for deeper fears

grounded in the organizational politics of nuclear energy. This is why Rice (2022) argues that radiophobia is a social phenomena that represents the public pronouncement of mistrust in nuclear authorities, rather than an acute fear of radiation.

When attention shifts from radiation in the abstract to radiation associated specifically with nuclear power, fear extends well beyond the measurable health impacts of a potential meltdown. As William Kinsella (2005) argues, nuclear energy is structured through four enduring discursive themes: mystery, potency, secrecy, and entelechy. In organizational terms, *mystery* refers to the arcane character of nuclear science and the concentration of knowledge among a small group of experts (p.53). *Secrecy*, widely noted in literature (Taylor, 2007; Zonabend, 1993), reflects the military origins of nuclear technology and the institutional cultures of classification and information control that persist within civilian nuclear governance. Together, these themes produce a second form of invisibility beyond radiation itself: the invisibility of control, knowledge, and oversight surrounding a potentially hazardous technology. This condition is further intensified when retrospective studies reveal historically lax attitudes toward radiation exposure, undermining claims of institutional competence. As a result, deficiencies in risk communication do not merely leave the public uninformed; they actively amplify perceptions of danger and erode trust in nuclear authorities tasked with managing radiological risk. Compounding this dynamic is the fact that trust is not a stable or transferable attribute. As Sjöberg (2001) demonstrates, public recognition of expertise does not automatically translate into confidence that experts fully understand or disclose the hazards associated with a given risk.

The Cultural Production of Toxicity Discourses

Toxicity is not specific to radiation, it qualifies all types of substances, from chemical cleaners, to pesticides and poisons. However, in the arena of energy production, nuclear energy endures the label of toxicity acutely. Toxicity represents the paramount of personal risk. Whether it be a label on a chemical cleaner, or a description of a problematic person, the *modus operandi* is to keep ‘toxic’ away. Buell (2001) defines toxicity discourse as “expressed anxiety arising from perceived threat of environmental hazard due to chemical modification by human agency” (p. 31). This expressed anxiety reflects Beck’s (1992) observation that, within risk society, social rationality and scientific rationality lack harmony. In this context, fears surrounding toxicity and environmental and bodily harm stand in tension with the rapid expansion of inherently risky energy systems. Currently, toxicity discourse permeates through everyday metrics such as air and water quality indexes, and through cultural productions such as books and films. Films that dealt with toxicity discourse in the 1970s were not akin to the stylized lawyer dramas we received in the 2000s such as *Erin Brokovich* (2000) and *Michael Clayton* (2007), nor big Hollywood blockbusters of recent time such as *Contagion* (2011) or *The Last of Us* (2023-). Instead, environmentalist led documentaries, and the 1979 release of *The China Syndrome* played a pivotal role not only disseminated toxicity discourse but resetting radiation through scientific and health related concerns (Lynch, 2012, p.333). Many scholars have chronicled this impact of popular culture on fear of radiation (see Matthews, 2012; Weart, 2012; Torry, 1991), with nuclear energy uniquely generating a body of imagery and narratives more closely aligned with science fiction than any other energy source. For example, hydroelectric power has not generated comparable cultural narratives, despite the substantial risks associated with dam failures.

In 1975, Typhoon Nina ripped through China, and a series of dams failed, including the Banqiao Dam. The subsequent floods killed 26,000 people, with an additional estimated 145,000 dying from epidemics via water contamination (*Encyclopedia Britannica*, n.d.). The Banqiao Dam was built for hydroelectricity generation, and akin to the Fukushima disaster, the blame for the infrastructure failure didn't rest solely on the intensity of the natural disaster, but also due to political incompetence and engineering issues (Kingston, 2012). The legacy and death toll of the disaster isn't nearly as well known or regurgitated in debates over energy source risks nearly as much as events such as Three Mile Island, a partial meltdown with zero fatalities and negligible environmental effects. If we extend this to coal power, while nuclear energy flailed in the 1980s and 90s, global coal power production rose steadily between 1970 and the mid 2010s (International Energy Agency, 2021). Surprisingly, discourses of toxicity never attached to coal power as strongly as they did to nuclear energy, despite the significant health risks associated with living near coal plants. The research on coal power plants is harrowing, as the emanating particulate matter pollutes the environment and leads to heightened rates of bronchitis, asthma, and anemia (Puljic et al, 2019; Amster, 2021; Datt et al, 2023). In the early 1970s, the mining of coal displaced acres of land with polluted waterways and landscapes; the subsequent ash produced is dumped into landfills (Weart, 2012, p.199). The uneven attachment of fear to nuclear power, despite comparable or greater harms from other energy systems, reveals how risk discourse operates culturally through toxicity.

The uneven distribution of fear points to a deeper mechanism shaping energy risk perception, which is rooted not in measurable harm, but in how invisibility and toxicity operate psychologically sustaining anticipation and anxiety. In his book on nuclear waste, van Wyck

(2005) writes, “In one sense, nuclear and ecological threats mimic the structure of trauma. That is, because we focus on the event (on threat’s actualization, on the disaster) ecological threat can itself be retroactively constituted and, thus, gain a kind of uncanny aura, leading to a condition of paranoia of toxicity and contamination” (p.111). Van Wyck is claiming that people begin to fear toxicity, not necessarily because they are contaminated, but because the uncertainty and invisibility create a psychological condition of constant suspicion and anxiety. Nuclear accidents happen in real time, but the fear they create is retroactive: paranoia persists because the threat of unseen radiation never fully goes away. This helps explain why toxicity discourse adheres so strongly to nuclear energy: it combines the invisible, harmful qualities associated with toxins with a history of meltdowns and bombings. Coal shares the first element, but not the second, which is why it doesn’t produce the same ongoing anticipation or fear. If risk is the anticipation of destruction that has not yet happened, then toxicity discourse serves as a signal of a potential nuclear calamity. It is in Beck’s terms, the call to action for the not-yet event (Beck, 1992, p.33). In this way, toxicity discourse transforms nuclear risk from a past event into a permanently anticipated future, anchoring fear not in exposure itself, but in the enduring possibility of catastrophe.

3. Nuclear Energy and Political Economy Risk

In popular discourse, the risks of nuclear energy meltdowns are framed primarily in terms of environmental and health consequences, while their equally significant political and economic fallout receives far less attention. Beyond their immediate material harms, nuclear accidents fundamentally recalibrate the political economy of nuclear energy by reshaping the balance between regulatory oversight, public trust, and cost. One of the clearest indicators of this

recalibration is the sharp contraction in nuclear construction rates following major meltdown events. After Three Mile Island, the U.S. NRC introduced a litany of safety standards to increase the regulatory oversight of nuclear energy sites, including regular plant safety analyses (U.S. Nuclear Regulatory Commission, n.d.). This led to many projects in the U.S. being delayed or cancelled. After Chernobyl, regulatory tightening around new nuclear construction was constrictive enough to essentially halt all new development, especially in the United States, where construction flattened after 1990 (U.S. Energy Information Administration). Some nations didn't bother to explore the possibility of constructing new nuclear, and banned nuclear energy outright such as in Italy, or imposed a moratorium on expansion, such as Ukraine. Following Fukushima, countries such as Japan and Germany pursued nuclear phaseout strategies, decommissioning reactors as the political costs of continued operation came to outweigh their energy benefits. In what follows are examples of what specific political and economic issues arise post-meltdown, and an examination of the failed nuclear renaissance. This informs a risk perception analysis in which nuclear energy's political economy risk profile is understood as systemic, rather than confined to specific events.

Events - Nuclear Energy and Political Economy Risk

Nuclear Powerplant Meltdowns and Political Economic Impacts

The three major nuclear powerplant meltdowns, TMI, Chernobyl and Fukushima, all had a tangible impact on risk perceptions of the environment and health, however, perhaps covered less extensively is their economic impact, and effect on the political will to construct nuclear power. Major nuclear accidents expose more than technical failure; they reveal how political authority, economic incentives, and risk governance intersect under conditions of crisis.

Examining nations after nuclear accidents, shows how meltdowns function as political-economic rupture points, eroding trust, reshaping policy, and recalibrating the viability of nuclear energy.

On the political side, the loss of institutional trust has a variety of effects. In Japan, following the events of 3/11, Prime Minister Naoto Kan resigned amid public anger over his handling of the earthquake and the subsequent nuclear power plant meltdown. Detailed in his book on Fukushima, Elliot (2013) claims that primarily, the revelations of the handling of Fukushima led to an erosion of trust between the nuclear industry, the government and the general public. Leading up to the meltdown, political and economic decisions created the conditions in which a disaster could unfold. For example, the design of Fukushima wasn't arbitrarily technical, rather the nuclear energy policy of the nation led to siting many reactors at in a single location, leading to the accident being much worse than it needed to be (Jukaru, 2013). The political project of nation-building and modernization served as the backdrop driving the decision to build the powerplant in a known environmentally hazardous zone rife with earthquakes and tsunamis (Pritchard, 2013, p.127). In this vein, it is also key to recognize that the political dimensions of nuclear energy are also economic. The Tokyo Electric Power Company, in charge of the plant, took a number of shortcuts leading up to the meltdown, including falsifying documents during the casting of a containment vessel at reactor number four (Perrow, 2011). Fukushima reveals how political authority, economic incentive, and technological risk become mutually reinforcing, producing accidents whose consequences extend beyond environmental and health impacts.

The economic tolls are hard to calculate. In a joint report on International nuclear law by the IAEA (International Atomic Energy Agency) and the NEA (Nuclear Energy Agency), one account of the economic impact of Chernobyl reads,

“Equally sobering was the realisation of the costs of the damage incurred, both on individual and societal levels – costs which resulted from loss of life, personal injury and illness including the effects of psychological stress and other mental health problems, property damage, economic loss, damage to the environment and other socio-economic disruptions. The range of damage suffered seems almost limitless. No precise figures are available, but the costs of the accident over the last two decades are estimated to have risen to the level of hundreds of billions of dollars.” (Schwartz, 2006, p.38).

There are many ways to measure economic risk. After the Fukushima meltdown, a host of research explored the different facets of post-meltdown economics, such as local property values (Yamane, 2013), macrofactors such as labour and GDP (Zheng & Wang, 2024), and the financial impacts on the energy industry (Rafindadi & Ozturk, 2016). While valuable, the more meaningful measures of political economic effect lie in the underlying policy responses to nuclear meltdowns. It is in these that the political and economic trajectories of nuclear power exist.

The ripple effects of nuclear power plant meltdowns on energy policy is where the political economic risk of nuclear energy materializes. For example, post Fukushima, many nations reversed course on their commitments to nuclear energy. In Germany, Fukushima led to a full reversal of Chancellor Angela Merkel’s commitment to nuclear energy, in Switzerland, approval to decommission the nation's power plants was set into effect, and in Italy, the nation

reaffirmed its commitment to a Chernobyl era ban of constructing nuclear power plants (Phillips, 2011). After Three Mile Island, despite no federal ban on nuclear construction, state-led moratoriums, public outcry and a regulatory tightening led to a 30 year construction freeze. The political economic implications of this are immense. No public trust means no political will, no technological development, gradual loss of economies of scale, obstructive regulatory conditions, and lack of political will. An example of what happens when a Nation attempts to reverse course against the weight of these political economic implications is explored with the next event of the 2000s nuclear renaissance.

The Failed Nuclear Renaissance

In the early 2000s discourses emerged that a nuclear renaissance, led by developments in the United States, was upon us. Mulling the possibility, Grimes and Nuttall (2010) cited climate change, energy security and depleted fossil fuel reserves as key reasons for the new interest in nuclear builds. In the United States, there was a fervor over new nuclear construction, the first in the 21st century, at Summer Nuclear Generating Station in South Carolina, and the Alvin W. Vogtle Electric Generating Plant (Vogtle for short) in Georgia. These two planned nuclear builds were part of a larger policy effort in 2005, as incentivized via the Energy Policy Act, to “derisk” nuclear energy (Welton & Harrison, 2025). These incentives ran into what Welton & Harrison explored as a variety of risks, namely regulatory and cultural risks, in what is a critique of using a few financial incentive tools to try and spur an energy transition. The Summer nuclear plant story quickly turned into a pariah. Scheduled to come online by 2018, in 2017 it was revealed that after spending an estimated 9 billion dollars, the reactors were abandoned at only 40% constructed (Plumer & Penn, 2023). This failure plunged the constructors of the reactors, Westinghouse, into bankruptcy. Vogtle in Georgia did eventually get built, however by the time

construction of Units 3 and 4 were completed, the overall costs of the project sat at around 30 billion dollars (Johnson, 2024), double the initial estimate of 14 billion. While nuclear builds in the U.S. were meant to spawn the nuclear renaissance, they instead invoked reflection on the industry wide risks plaguing new nuclear construction.

The political and economic lessons of the nuclear renaissance were partially a lesson in misframing. Nuclear energy expert Chris Keefer writes that the nuclear renaissance had many issues, including organizational failures and the loss of economies of scale during the quiet development period. The salient takeaway from this article however, is from the get go nuclear energy was misframed as a jumpstart power source, rather than the capital intensive, heavily regulated leviathan it is, due primarily to the environmental and health risks it poses (Keefer, 2025). Simply put, the issue of the nuclear renaissance was structural, as the context in which it emerged was not conducive to new nuclear construction (Toke et al., 2021, p.27). Kinsella et al (2013) note that even with subsidies and other financial incentives, the risks of nuclear projects mean that financing is always an issue, especially in a nation like the United States, where many utilities are privatized and profit is a clear motivation (p.282).

Risk Outcomes

Systemic Risk

The risk perception that continues to shadow nuclear energy's political economy is the view that accidents are not exceptional failures, but systemic products of the industry itself. Nations have tried to combat this through regulatory measures, essentially attempting to maximize safety while maintaining economic viability (Pemberton, 2017, p. 430); however, political will remains contingent on public trust, and once that trust is eroded, regulation alone is

insufficient to stabilize nuclear energy's political economy. It is this trust deficit, rooted in the cumulative legacy of accidents, mishaps, and institutional secrecy, that has come to define nuclear governance in the post-accident era. As Ash (2010) argues, the regulatory strategy surrounding nuclear power is less about closing knowledge gaps than about repairing trust gaps. Accordingly, the post-accident emphasis on safety, and the regulatory freeze that constrained nuclear expansion throughout the 1990s, was not solely a technical response, but a political effort to restore public confidence in a shaken industry. Risk scholars locate the origins of this condition within the very systems through which nuclear technologies are governed and organized. In *Normal Accidents*, Charles Perrow (1984) contends that failures emerge not from individual technological flaws, but from the tight coupling and organizational complexity of high-risk systems. Writing in the aftermath of Three Mile Island, he warned that further meltdowns were likely not because of nuclear energy's inherent danger, but because it operates as a system predisposed to failure.

While Perrow frames nuclear risk as an emergent property of tightly coupled technological systems, his argument opens a broader analytical lens through which risk is understood not only as technical failure, but as organizational and cultural practice. Although not directly focused on nuclear energy, Diane Vaughn's (1996) analysis of NASA in the lead-up to the *Challenger* explosion offers a closely parallel account of organizational risk failure through what she terms the "normalization of deviance" (p. 119). Vaughn shows how repeated acceptance of small anomalies became embedded within NASA's institutional routines, reinforced by a broader cultural reverence for technological achievement and the political pressure to perform as a symbol of national pride (p. 389). Together, Perrow and Vaughn demonstrate that technological

catastrophes rarely stem from singular, extraordinary failures; rather, they emerge from the accumulation of minor oversights normalized within organizational cultures. Perrow's conclusion was particularly stark: he argued that the systemic risk cultures surrounding nuclear energy were so inherently risky that widespread adoption should be abandoned altogether (Perrow, 1984, p. 304). As efforts to expand nuclear energy resumed under heightened safety standards, however, critical attention increasingly shifted away from accident risk toward economic viability. STS scholar and prominent nuclear critic Benjamin Sovacool contends that a nuclear renaissance would bring insurmountable costs like long construction time, overruns and unresolved waste management challenges (Sovacool, 2010, p.120). These concerns echo a broader body of scholarship from the 1990s and 2000s arguing that nuclear power is ultimately untenable not only because of safety concerns, but because its economic risks outweigh its potential benefits (Culley & Angelique, 2010; Cooper, 2012).

What is clear about the discourses of nuclear new builds in the 21st century is that they are prohibitive due to the economic costs. These discourses are predicated on examples of nuclear power plant builds which are plied with government subsidies, and yet run way over budget and longer than expected build times. The reality is, post Chernobyl, the regulatory regime tightened up safety protocols to a level which made constructing nuclear incredibly expensive. The fact remains that the "political winds" at the moment, or the culture of politics, shape science and technology more than anything (Jasanoff, 2005, p.21). These contemporary cost concerns cannot be understood without situating them within the historical regulatory shifts that reshaped the U.S. nuclear landscape after Three Mile Island. It may sound ridiculous to suggest that the U.S. regulatory system isn't favourable considering that the U.S. has the most

nuclear reactors and reactor capacity in the world. The reality however is that much of the development of the U.S.' reactor fleet happened in the 1970s, and more have closed in the last 20 years than opened. In the U.S. post TMI, nuclear development ground to a halt during a "regulatory freeze" in the 1980s and 90s. The uncertain and constant shifting in the regulation of nuclear power plants lead to a period of little development or innovation. Leading up to TMI, the AEC (Atomic Energy Commission) was dismantled as the public and political body in the U.S. questioned its lax oversight with respect to radiation, leading to the development of the NRC, which encouraged much stricter regulation around nuclear energy. The central mandate of the NRC was to ensure nuclear reactor safety, and regulation is framed through discourses of "containment" (Walker & Wellock, 2010, p.52; Toke et al., 2021, p.20). The reality according to Toke et al. (2021) however, is that U.S. safety regulation is politically mismanaged and inconsistent, leading to weaker safety standards, high economic costs (*Chapter 4*). This undermined public confidence and reinforces the sentiment that the industry as a whole is risky.

Regulatory Success

The failure of a nuclear renaissance and the uptick in regulation and risk doesn't have to be the full picture of current nuclear energy development. One nation can serve as the political economic model for building, maintaining and nationalizing nuclear energy. Having the highest share of energy production from nuclear, France is a global leader not only in reactor development and deployment, but a model for how to build a regulatory body. The centralization of energy as a state run enterprise means that the regulation of nuclear energy is also centralized. The keys to success in France are a centralized technocratic nuclear administration, the successful quelling of opposition, and the nationalized programme, meaning economies of scale for broader nuclear development (Toke et al., 2021; Sovacool & Valentine, 2010). Historically,

there is also strong political will to build nuclear power and public support (Chalmers, 2025). The centralization of the regulatory process means more efficiency in construction, less surprises, accurate cost estimates, and the streamlining of development. The conditions for this however were laid out, as Flynn (2003) argues that in France at the time, the public had a much greater trust in experts and politicians, laying out the path for a greater ease of development (p.337). Despite experiencing nuclear accidents, most notably in 1980, France, rather than slowing development, leveraged a highly centralized civilian nuclear program aimed at reducing oil dependence to implement rigorous regulatory standardization, prescreened reactor sites, and streamlined environmental review. This enabled an unprecedented buildout from 15 to 55 reactors in the 1980s alone, with supply chains so standardized that a new reactor could be completed every six years (Chalmers, 2025).

In Canada, regulations are much more aligned with the U.S. model. Canada has a centralized regulatory body, the Canadian Nuclear Safety Commission (CNSC), which, like the NRC, has sole jurisdiction over reactor safety. The CNSC also leads environmental assessments, while the energy policy, akin to the U.S., is delegated by the state or province. The main difference is that nuclear power builds in Canada are largely part of policy directives and are state sanctioned, whereas in largely deregulated parts of the U.S., nuclear energy's cost makes it less competitive in the energy market. In Canada, nuclear power more so is framed as public infrastructure vs in the US, nuclear energy is historically a politically charged technology. This point is made by Toke et al (2021) who claims that much of the regulatory culture in the U.S. is dominated by cultural bias against green policies and regulating private enterprises (p.14). It also helps that in Canada, utilities are largely publicly owned, unlike in the U.S. which has higher

rates of privatization. The political-economic risk for the future of nuclear energy in nations where utilities and companies are privatized lies in striking a regulatory balance: loosening requirements enough to make new nuclear energy economically viable, while maintaining safety standards that ensure the technology remains a credible alternative to carbon-intensive fossil fuels. This regulatory balance is in essence about the dispersion of risk according to Vanderheiden (2011), who claims that while you're reducing the broader scale risk of climate change, the acute risk of nuclear energy for the citizens in the vicinity of a powerplant is not a fair dispersion. He continues to argue that the best path forward is reducing both risks, and that the tradeoff isn't necessary.

Conclusion: The Price of Caution

This chapter has argued that nuclear energy is best understood not through isolated technical failures or discrete accidents, but through a set of enduring risk discourses that structure how nuclear energy is interpreted. Environmental, health, and political-economic risks emerge as mutually reinforcing domains through which nuclear energy has been rendered intelligible to the public. Across these domains, risk does not simply arise from radiation exposure or reactor failure; it is culturally produced, institutionally mediated, and historically sedimented through events and interpretations. Nuclear energy is thus both constituted by risk discourse and constitutive of new forms of risk perception. In the environmental domain, nuclear energy becomes emblematic of manufactured risk. From weapons testing to reactor meltdowns, radiological contamination destabilizes the boundary between nature and culture, producing anxieties about contamination and ecological harm. Health risk intensifies these anxieties through the invisibility and toxicity of radiation. Because radiation cannot be sensed directly, its

governance relies heavily on expert mediation and institutional trust. As demonstrated through cases of negligence, secrecy, poor communication, and ethical failures, radiophobia is not simply fear of radiation itself, but a rational response to poor systems of authority managing an involuntary and imperceptible hazard. Political-economic risk shows how environmental and health anxieties translate into regulatory, financial, and infrastructural consequences. Nuclear accidents function as rupture points that recalibrate public trust, political will, and investment viability. The tightening of safety regulation following major accidents, solidifies perceptions of nuclear energy as economically precarious and systemically risky.

Living according to mitigating risk doesn't come without its costs. The risk perception of nuclear energy essentially froze development between 1970-2000 through a regulatory approach which made nuclear power economically unviable. This in turn stumped innovation and development of a technology which is currently in high demand. Climate change and the increase in energy demand has revealed the need for many nations to divest from fossil fuels to cleaner sources which can handle base load electricity needs. For example, if we take Germany, which completed its nuclear phaseout in reaction to the Fukushima meltdown, its denuclearization process replaced clean KW hours of energy with fossil fuels (primarily coal), the economic costs amounting to 12 billion dollars per year, 70% attributable to increased mortality associated with air pollution (Frum, 2021; Jarvis et al., 2022). The global phase out of nuclear energy in 2021, pumped roughly 140 million metric tonnes of carbon dioxide into the atmosphere (Núñez-Mujica & Wang, 2022). This is not to say nuclear energy isn't without risk, but that risk isn't static, and moves through different contexts. In the next chapter I explore how we are currently in an energy context of decarbonization, wherein the risks of nuclear energy are

being reframed primarily through its zero carbon dioxide emissions. This is part of a broader effort by the nuclear energy industry to reverse the risk discourses associated with nuclear power production, and cast it in benevolent terms.

Chapter 4

Recasting Nuclear: The Role of Discourses of Quantification and Scale in Risk Communication

Introduction

In the summer of 2023, Ontarians were treated to a nuclear energy advertising campaign, an anomaly within the nuclear industry. Dubbed “Recast Nuclear,” Ontario Power Generation (OPG), the provincial utilities company, deployed posters throughout Toronto subway stations and a movie trailer style advertisement that played prior to film screenings, attempting to reframe nuclear energy through narratives of safety, efficiency and reliability. The theme of the campaign is a response to pop culture narratives which are driving nuclear energy discourses. The recent success of shows such as *Chernobyl* (2019), *Fallout* (2023-), and films such as *Oppenheimer* (2023) reaffirmed nuclear energy as a fear inducing protagonist. Beyond the posters, OPG created an education campaign rife with facts, quantifiable metrics and metaphors aimed at reversing the status quo of nuclear energy as a risky technology. This strategy is in line with the broader nuclear energy industry, and reflects appeals to *logos*, a rhetorical device that signals rationality through the use of facts and data. This chapter analyses the “Recast Nuclear” campaign through a method of discourse analysis, uncovering two arguments. The first is that the campaign utilizes discourses of quantification in order to reframe nuclear energy in benevolent terms. This is achieved through a comparative mechanism, in which nuclear energy is compared to other energy sources and against the backdrop of its own legacy. Discourses of quantification are rhetorical devices which utilize numerical data to underscore legitimacy and rationality (Mudry, 2010). The second argument is that the recast campaign follows similar discursive trends in the nuclear energy industry, which use quantification as a relational function, serving a

broader effort to classify energy sources as either “clean” or “dirty,” with nuclear power situated in the former category.

Rather than operating as neutral measurement, quantification here functions as a device which translates scale into a means of ordering risk. The formatting of the campaign is through the valorization of facts over the imposition of fiction, as read in one of the posters that could be seen around Ontario (figure 4.1.). The context for this campaign arrives at a crucial time, as the demand for energy increases and the impetus of decarbonization remains central to national and provincial energy policy. Ultimately, through the use of quantification and scale, nuclear power is vying to be categorized as the rational, clean and progressive choice. The campaign underscores that quantification and scale operate as more than a communicative device; discourses of quantification function as mechanisms that order energy systems, structure risk comparisons, and shape what counts as credible energy sources. The goal of this chapter is not only to establish how discourses can shape energy discussions, but also how the nuclear industry reflects national energy policies and priorities. While OPG is owned by the provincial government of Ontario, other non-affiliated industry communications which are referenced throughout this chapter, also reify that the linguistic framing of energy discourses can reflect and reinforce policy positions (Scrase & Ockwell, 2010).

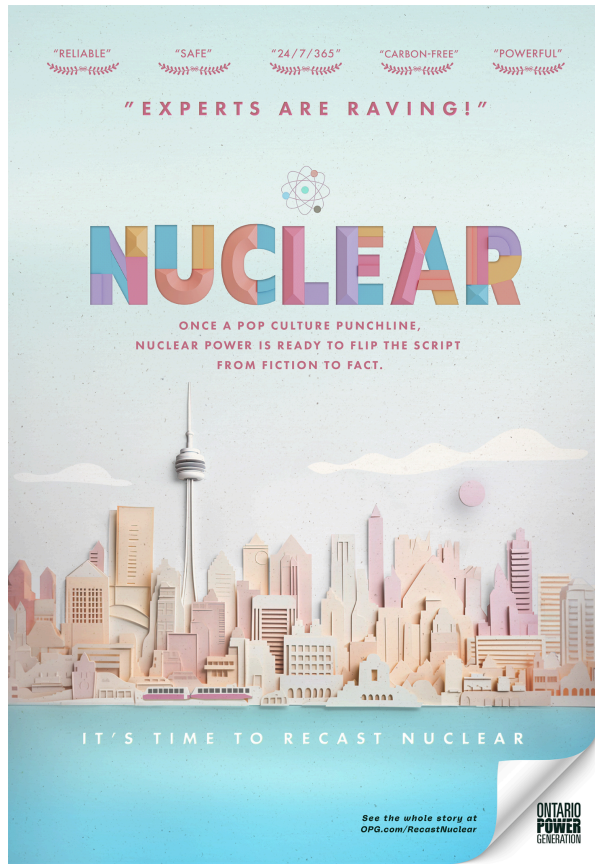


Figure 4.1. One of the posters from the recast campaign. The tagline reads, “Once a pop culture punchline, nuclear power is ready to flip the script from fiction to fact. *Note.* Screenshot of a campaign poster from *Recast Nuclear* (Ontario Power Generation, 2026).

Current Context

The recast nuclear ad campaign seen across Ontario, is a manifestation of the broader provincial and federal direction of nuclear energy policy. The overall policy and regulatory context in Canada is very conducive towards nuclear energy, as both provincial and federal governments signal that commitment to nuclear power is a key factor in their 2050 net zero emissions goals. Federally, Canada is going all in on Small Modular Reactors (SMRs), as they are positioned by the government as a strategic clean energy technology to support decarbonization, energy security, and regional economic development. They are explicitly referenced in Canada’s 2030 Emissions Reduction Plan, Net Zero by 2050 framework, the

Canadian Critical Minerals Strategy, and the SMR action plan, which has set aside 70 million dollars for SMR research and development (SMR action plan, 2022). Provincially On June 12th, 2025, government of Ontario released its Energy for Generations plan, a comprehensive expansion of a previous paper; Ontario's Affordable Energy Future: The Pressing Case for More Power. This plan outlines a major expansion of provincial energy generation capacity by 2050, prioritizing affordability, integration, and Indigenous participation. This plan projects up to 75% more electricity on the grid by 2050 and highlights nuclear energy as Ontario's clean, reliable, low-cost anchor (Government of Ontario, 2025). Projections anticipate adding an additional 17,800 MW of nuclear power, more than doubling our current installed capacity. Additions to nuclear energy capacity will come via refurbishments, optimization and new nuclear.

Refurbishments are slated at Darlington unit 4, Bruce units 3 through 8 (with the potential for a second refurbishment for units 1 and 2) and Pickering units 5 through 8. Bruce power plans to optimize its existing units through innovation and new technologies. New nuclear builds will come in the form of four SMRs at the Darlington site, and large-scale nuclear builds at the proposed expansion at Bruce C, and OPG's (Ontario Power Generation) Wesleyville site.

Refurbishments have become a specialty in Ontario, as the recent Darlington refurbishment was on time and on budget, prompting the greenlighting of the Pickering refurbishment, and framing this project as a key investment in Ontario and Canada's future economy (Ontario, 2025).

These policy positions reflect the biggest nuclear energy additions in Canada in its history. To sell this to the general public, recasting nuclear means reorienting many of the risk perceptions cited in Chapter 3, that individuals may have. The recast campaign is the first

attempt to do this. Understanding the communicative strategy of Recast Nuclear requires first examining quantification and scale as broader cultural practices.

Quantification & Scale

The Recast Nuclear campaign highlights a defining feature of modern society, in which quantification functions as a marker of cultural value and legitimacy. Porter (1996) explores this sentiment and finds that the pervasiveness of quantification, is more than a tool in claims to objectivity, rather it functions to delineate social order. Hacking (1990) extends this argument historically, illustrating how quantification evolved from a technical tool into a governing logic of modern culture. He argues that the introduction of numerical data to organize primarily taxation and the military, quickly became a new social order of statistics and probability. Throughout history, we have reified demographic, health, crime, and a number of other quantifications for the social purposes of organizing populations, providing insurance, allocating resources, amidst other reasons. This is the basis for Foucault's (1977; 2008) theory of biopower, whereby socially constructed statistics are governance tools to condition populations. This extends to current scholarship on governance through quantification (Berman & Hirschman, 2018; Supiot, 2017). In the late 20th century, several STS scholars analyzed the societal trends of the last century, and argued that numerical reasoning is a key epistemological tool to both claim objectivity and manage uncertainty. Several make the argument that quantification is a socially constructed practice and used strategically by bureaucratic entities (Latour, 1987; Porter, 1996), others examine how quantification is used to reify inequality (Espeland, & Sauder, 2016; Fourcade, 2019), and how quantification is a key way to manage and organize populations (Desrosières, 1998; Foucault, 1977, 2008; Hacking, 1990). The fundamental anchor in the

cultural attachment to quantification is an underlying trust in numbers. The value of quantification lies in its ability to represent claims as factual or truthful through socially and culturally conferred validity (Porter, 1996, p.34).

Trust in numbers and the valuing of quantification as epistemological truth means that discourses of quantification can be used as rhetorical strategies. In terms of nuclear energy, this strategy entails reorienting the power source in terms of numbers rather than narratives. There are a number of key quantifications, such as CO₂, radiation measurements, land use and KWh (Kilowatt hours), that if used correctly, rhetorically posit an advantage for nuclear power. The rise of numeracy to apply values toward a phenomena is well researched (Cohen, 2005), however within the context of nuclear energy, the impact of the use of statistics and quantifications is predicated using the social and cultural value of scale (Carr & Lempert, 2016). In the past, nuclear energy was often rhetorically reified through binaries (good & bad atom, apocalypse vs utopia) which cast the power source in an unwinnable quandary. Now however, the nuclear industry is implementing scale in their communications, with quantification as a strategy to offer the atom not as a utopian saviour, but as the smarter choice. A classic example is through anecdotes like, “Nuclear power has a minimal carbon footprint of around 15–50 grams of CO₂ per kilowatt hour (gCO₂/KWh). In comparison, the average footprint of a gas-powered generator is around 450 gCO₂/KWh and for coal it is around 1,050 gCO₂/KWh” (Serin, 2022). Here, quantification serves as an entry point for legitimacy, while scale functions to amplify nuclear energy’s comparative advantage. The nuclear industry using scale to compare it to fossil fuels is an idea taken from classic risk theory, wherein hazardous products can lessen their risk impact by dramatizing the risks of the others (Beck, 2009). The use of quantification and scale have

flooded nuclear energy industry communications. In its 2024 report, Bruce Power not only highlights nuclear energy's share of Ontario's electricity generation, but visually and rhetorically emphasizes its 51% contribution by presenting it alongside smaller shares for hydro (24%), gas (16%), wind (9%), and solar/biofuel (>1%) (Bruce Power, 2025).

Scale is a widely utilized discursive tool and a feature of popular culture. In the novel *Gulliver's Travels*, Jonathan Swift utilizes scale as a satirical method to pinpoint both human triviality and frailty. Similarly in the well known biblical story of the Tower of Babel uses the scale of the construction of the tower to reach the gods as a commentary on hubris. There are countless stories in which scale is used as a literary tool, such as *The Lord of the Rings* (tiny hobbits achieve a mammoth task), and *Alice's Adventures in Wonderland* (Alice's constant shrinking and growing as a reflection of power and self perspective). These ideas play on certain philosophical underpinnings of scale, such as Kant's sublime which is predicated on the idea that the sublime exists in relation to the limit of human conception. The sublime as an inexplicably beautiful but terrifying force only is so due to its scalar relation to human limit and finiteness (Merritt, 2018, p.4). In Phenomenology, scale underlines how the "lived body" interacts with the world and to create human perception (Merleau-Ponty, 1945). In C. Wright Mills' *Sociological Imagination* (1959), scale is used to frame individual experience within larger social structures. Quantification, when scaled, creates categories which epistemologically reify the better option. This is the case in energy politics, which often scales discourses of quantification to qualify where risk in comparisons.

Risk

In chapter 3, I analyzed three main areas of risk in which nuclear energy is often materially and discursively situated: the environment, health, and political economy. The communicative path forward for the nuclear industry in combating risk perception is refocusing the conversation on quantification. In a variety of ways, quantification spawned as a risk mitigation tool. The pervasiveness of quantification is a byproduct of the waning of personal trust, and the need for numerical objectivity as a social hedge (Porter, 1996, p.117). Numerical objectivity then provides the infrastructural basis through which risk can be governed. Objectivity is historically intertwined with risk in both the need to describe it and manage it (Desrosières, 1998, p.7). Nelkin (1989) further explains that risk analysts deploy quantitative analyses as communicative devices to reassure the public about costs and benefits (p. 99). Framing risk as calculable not only enables prediction but also delineates acceptable pathways for decision-making. In other words, if risks are calculatable, it helps predict the future, and lays out the path of least resistance. Within a highly technical society, this reliance on quantification is not optional: as Luhmann argues, modern societies confront technological risk primarily through technical forms of reasoning, attempting to manage the problems of technology by technical means themselves (Luhmann, 2002, p. 90). In this vein, nuclear energy simply needs to quantify its technical merit against other similar technologies, in order to argue a positive risk case.

Within contemporary energy politics the key quantification that nuclear energy can lean on is CO₂ emissions. The keeling curve, discovered in 1958 by Charles David Keeling, is a way to measure the amount of “parts” of Carbon Dioxide in a million units of atmospheric gasses.

While the curve isn't the first instance of atmospheric measuring, its simplicity created a climate revolution whereby the relationship between humans and the environment can be easily quantified and scaled through the mediation of CO₂ (Howe, 2014). The PPM (parts per million) of CO₂ kicked off a host of benchmarks in which humans could scale their environmental impact, and guided international environmental policy. The first of which was the Kyoto Protocol, an international and legally binding treaty to cap greenhouse gas emissions. More than just CO₂, different quantifications can spur further political action. In 2015, nations worldwide convened to sign the Paris Agreement in response to the growing impact of climate change. A number was set: we must limit global temperatures so they do not rise 1.5 degrees celsius above pre-industrial levels. The 1.5 degree number is slightly arbitrary (Henriques, 2024), as reaching a fraction of a degree above or below the 1.5 benchmark won't yield wildly different climatic results, however, this number is important because it catalyzes national environmental and energy policies. For example, the preamble of the Canadian Net-Zero Accountability Act (2021) is framed through the idea of limiting emissions to 1.5 degrees.

These quantifications are important because they create the context in which risks can be qualified as acceptable or not. In *Risk Society: Towards a new modernity* (1992), Beck questions at what point does the line between acceptable and unacceptable risks become untenable. The answer is complex, in that it is not the pure domain of science to quantify the line, rather it is the interplay between science, social context, business, politics and ethics (p.29). This builds off Douglas and Wildavsky (1982) initial claim that the public perception of risk and its acceptable levels are "collective constructs" (p.186). In this vein, the social and political context of climate change in conjunction with improved safety and lower accident probabilities make nuclear

energy's overall risks more acceptable. The second point remains salient, as technical analyses are still important in the social construction of risk (Renn, 1992). The recast campaign and the use of quantification then is an attempt to demarcate thresholds where nuclear energy sits on the acceptable side. Within the quantification context of CO₂ reduction, nuclear energy holds a competitive advantage.

The nuclear industry is jumping on this opportunity, using rhetorical tools at its disposal to amplify the benefits of nuclear energy, while amplifying the risks of other sources. The interplay between scale and risk is key in this discussion. Climate change, public health, and the financial sector are all constantly operating on a scale of risks. The COVID-19 pandemic provides a recent example of the challenge of scaling risk, as the public-health threat of the virus existed alongside the secondary but substantial risks associated with prolonged social isolation and mental-health deterioration. While orders to stay home curbed covid transmissions and potential covid-related deaths, researchers found that children's mental health specifically suffered due to lack of social interaction from being out of school, extended screen time, less physical activity, and worsened sleep (Ng & Ng, 2022). I bring this example of the pandemic to highlight a key takeaway from the interplay between quantification, scale and risk. Not all risks scale cleanly. As exemplified by the campaign, nuclear energy is contending with fossil fuels in the domain of emissions, renewables in the domain of efficiency, and itself in the domain of safety. The campaign inserts nuclear energy into new discursive territory, attempting to sever it from the histories and risk perceptions mapped in the first three chapters.

Methods

This research employs qualitative discourse analysis to examine how nuclear energy is framed, legitimized, and contested across the recast campaign and industry communications as a whole. Discourse in this chapter is treated not merely as representation, but as a constitutive force that shapes how technologies, risks, and responsibilities become intelligible and governable. This is a Foucaultian concept, the idea that discourses don't reflect objects of knowledge, but are practices that form the objects of which they speak (Foucault, 1972, p.49). The analysis focuses on recurring narratives, metaphors, categories, and forms of quantification through which nuclear energy is positioned in relation to climate change, risk, and technological progress, in order to connect patterns of language to the meanings they create (Johnstone, 2017, p.27). By situating contemporary communications within their broader historical and political contexts, the analysis reveals how discursive strategies function to reorient nuclear energy's social legitimacy, and becomes a critical space to analyze the production of nuclear based knowledge. While I analyse industry communication, the context in which they are situated reflect the broader policy directives of the moment, reinforcing Scrase & Ockwell's (2010) argument that linguistic frames reinforce policy positions.

STS and energy humanities has a strong history of using discourse analysis to uncover the realities of technological and scientific development. For example, in *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process* (1995), Hajer demonstrates how environmental knowledge is produced through the mutual shaping of discourse and policy practice. For a broader analysis, Dryzek (2013) explores environmental discourses through different typologies to uncover how rhetorical tone informs political

motivations. Within energy, there are a variety of uses of discourse analysis, including the role of narrative in national socio-technical transitions (Hermwille, 2016; Sovacool & Hess, 2017), the impact of discourse on sustainability politics and energy transitions (Kern, 2012), and specific discourses around energy sources such as coal power (Leipprand & Flachslund 2018), nuclear power (Garud et al, 2010; Gamson & Modigliani, 1989), geothermal energy (Stauffacher et al., 2015), and wind power (Szarka, 2004). Building on this tradition, this study adopts discourse analysis not simply as a descriptive tool, but as an analytical framework through which nuclear energy knowledge is actively produced. Simply put, this analysis focuses on texts, how they impact the production of meaning, and how they are culturally embedded (Fairclough, 2003). The following section applies this approach to the recast nuclear ad campaign material, tracing how specific discursive tactics of quantification and scale, reflect an attempt to reorient nuclear energy's relationship to risk.

The Campaign

With the current contemporary moment of progressive energy politics being predicated on risk, quantification and scale, it was incumbent upon OPG to centralize that as part of the campaign. The posters strewn across Ontario as well as the recast promo that played throughout theatres (along with a novelty popcorn bag with nuclear tidbits across it) were set up to create intrigue into the campaign, and ultimately visit the recast nuclear website. The website hooks visitors in with a bold tagline, "Experts are raving! 'It's time to flip the script on nuclear power - the clean energy source the world needs.'" (Ontario Power Generation, 2026). The site is fairly simple and has a clear strategy of bombarding visitors with stats, facts and scale to change minds about the importance of nuclear energy for the future, and the actual risk nuclear energy poses presently. The website is broken down into subsections that have a list of "FACTS," as shown in

figure 4.2. The use of facts in science and technology is an effort to crystallize a statement to the point where it becomes unquestionable, or black boxed (Latour, 1987, p.131). Each statement either utilizes quantification or scale, or both, as a rhetorical tactic. I employ discourse analysis to uncover the context and the ultimate goal behind each claim. I break the claims up into two sections. The first uses discourses of quantification to rethink the risk perceptions associated with nuclear energy. The section uses discourses of quantification to compare nuclear to other energy sources, thereby framing nuclear energy in a positive light.

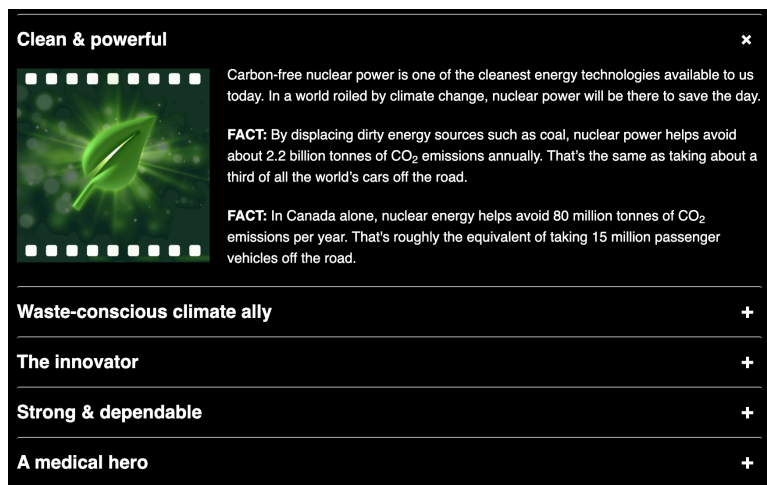


Figure 4.2. The recast nuclear website, showing the format of the campaign. Each subsection is expandable, revealing “FACT(s)” which cast frame nuclear energy in a benevolent light. *Note.* Screenshot of a campaign from *Recast Nuclear* (Ontario Power Generation, 2026).

Nuclear Energy vs Risk Perceptions of Nuclear Energy

1. **FACT:** About 10 uranium pellets can power the average Canadian home for a year. In a CANDU reactor, hundreds of these pellets are loaded into 28 or 37 half-metre-long fuel rods, which are then grouped into a cylindrical fuel bundle the size of a fireplace log. One fuel bundle can provide enough power for about 100 homes for 18 months (OPG, Accessed 2025).

And...

FACT: The used nuclear fuel that a single person would generate over their entire lifetime if they relied exclusively on nuclear energy would be small enough to fit in a standard 355 ml soda can.

Rhetorical Tactic: Material Diminution

The linkage between the material scale of nuclear energy and the scale of risk is an important convergence. The rhetorical tactic of material diminution is valuable in the face of a nuclear history which is culturally associated with immensity and catastrophe. The discourses that emerge from nuclear accidents result in perceptions of risk which balloon the scale of nuclear threat. For example, after Three Mile Island, the media response exceeded the material impact of the meltdown. One New York Times article recaptured the horror of the event in an animated article which detailed the reactor “ripping apart” 4 foot thick concrete walls, and an anecdote from one scared 6 year old who said “Something's wrong with the air... My mommy told me it could kill me” (Ayres Jr., 1979). The actual environmental and health impacts were negligible, but the high risk perception is a clear example of the social amplification of risk (SARF). SARF is a framework which claims that the physical impact of an event doesn't determine the scale of its risk perception, rather the amplification or diminishment by social actors does (Kasperson et al., 1988). Additionally, Hannigan (1995) argues that risk communication is rarely neutral, and risk “arbiters” tend to side with risk generators, which in turn relay information to risk informers, like news sources (p.117). This leads to amplification of risk beyond the actual impact of an event. In order to counter a legacy of amplified risk, OPG has turned to strategies of material minimization, seeking to shrink the perceived threat of nuclear energy by reframing its physical scale as small.

Reframing nuclear energy's physical scale is not a simple task, as its history is laden with 'bigness'. During the cold war, the measuring stick of dominance between the United States and the Soviet Union was both the size of the weapons they were testing, and the amount they could stockpile, and by the late 1980s the two nations shared a stockpile of over 60,000 nuclear weapons (Norris & Kristensen, 2006). The 15 and 25 kiloton bombs (Little Boy and Fat Man) dropped on Hiroshima and Nagasaki respectively, were small compared to the ballooning size of bombs which were consistently tested over the next 4 decades. In 1954, the U.S. dropped a bomb 1000 times more powerful than Little Boy in the Pacific Ocean adjacent to the Marshall Islands. This test destroyed mass amounts of coral and local ocean wildlife, and infected Marshallese islanders with severe radiation sickness, leading to a legacy of cancers, radiation induced illnesses, and miscarriages and stillborn babies (Hennigan, 2024). Between 1945 and the most recent North Korean nuclear test in 2017, over 2000 nuclear weapons have been detonated in either the atmosphere or underground (Arms Control Association, n.d.). In this context, OPG's soda can and fireplace log comparisons operate as rhetorical devices designed to shrink nuclear's material scale, countering a century of associations with destruction and planetary-level risk by anchoring it to familiar household objects.

The soda can and fireplace log do more than communicate physical scale, as they work symbolically, intervening in nuclear power's cultural imagery. The massive icon of the mushroom cloud is a testament to the immense power of a nuclear bomb, the largest of which came from the Russian Tsar Bomba (Emperor Bomb) test. This 50 megaton bomb (3300 times more powerful than the bomb at Hiroshima) detonated and released a mushroom cloud that reached 60 miles high and 42 miles in diameter (Wellerstein, 2021). These displays of physical

power did not remain confined to the realm of warfare, they became cultural symbols of the energy source itself. Symbolism bleeds into rhetoric, as the phrase “going nuclear,” is used to describe a level of anger and escalation perceived as destructive, reinforcing nuclear power’s cultural association with excess and loss of control. Massive cooling towers are commonly associated with nuclear energy and are often portrayed as menacing in popular culture, such as at the Springfield Nuclear Power Plant in *The Simpsons*. This association was made when the first images of Three Mile Island after the accident were released, with the ominous looking cooling towers becoming icons of the meltdown (Dunaway, 2015, p.132). In practice, however, cooling towers are not unique to nuclear facilities, as they are also used at fossil-fuel power plants and function primarily to release steam as part of routine thermal cooling processes. Against this backdrop of large-scale and often distorted nuclear symbolism, recent nuclear energy communication efforts have increasingly emphasized smallness as a counter-framing strategy.

This rhetorical work covers all aspects of nuclear energy, especially with respect to nuclear waste, which remains a material and cultural burden. In a 2023 research report for the Canadian Nuclear Association, polling found that 87% of women and 71% of men are concerned about the storage and management of nuclear waste (Environics Research & Canadian Nuclear Association, 2023). The nuclear industry has responded to this uneasiness largely by quantifying the actual scale and materiality of nuclear waste. First a popular anecdote is reassuring people that nuclear waste is in fact a solid, and not a “glowing” green goo (U.S. Department of Energy, 2022). The other industry standard is to scale nuclear waste down by claiming that the spent fuel in the U.S. could fit onto one football field (U.S. Department of Energy, 2022), and in Canada, 9 hockey rinks (Nuclear Waste Management Organization, n.d.). With that impact easy to

conceptualize, it is comforting to know that one's own individual contribution is a mere 355 ml soda can worth. These examples illustrate a deliberate communicative strategy: by rendering nuclear waste tangible and finite, industry actors seek to counter abstract fears by reframing waste as a manageable material problem rather than an overwhelming existential threat. This is evident in the recast campaign's nuclear waste poster, which relies explicitly on strategies of diminution, through the symbol of a magnifying glass (see Figure 4.3).

In the recast campaign, by focusing on something already small, such as uranium pellets, you can diminish the scale of the rest of the reactor by proxy. Many nuclear energy proponents have adopted this method, such as Isodope. Isodope is the self-proclaimed world's first nuclear energy influencer. She uses video tropes on tiktok to trick the viewer into thinking they are watching a different kind of video such as a makeup tutorial, before unloading tidbits about the positive impact of nuclear energy. For example in a recent video on explaining how nuclear power works she makes the following statement, "In there (nuclear reactor) is the nuclear fuel, uranium pellets, roughly the size of gummy bears" (Isodope, 2022). This work is also attempting to flip the narrative of potency, from Kinsella's (2005) four master themes of nuclear energy. From cold war legacies to environmental threats, the genie of nuclear energy existed in its potency, or potential to cause destruction (pp.59-60). Now the minute scale of the power units of nuclear reactors use their potency for an energy revolution. As an amusing blog called "Nuclear fast facts for the dinner table" reads, "The amount of energy contained in a pellet of uranium fuel the size of a gummy bear is equivalent to 149 gallons of oil and 2,000 pounds of coal, and it could power a home for two and a half months" (Derr, 2022). In this discursive reversal, the same potency that once signified nuclear catastrophe is rearticulated through the tiny scale of

“gummy bears” as a promise of efficient and clean abundance. These strategies of material diminution reveal a concerted effort to reconfigure nuclear energy’s historical association with overwhelming scale, and recasting potency as a contained source of controlled, productive power.

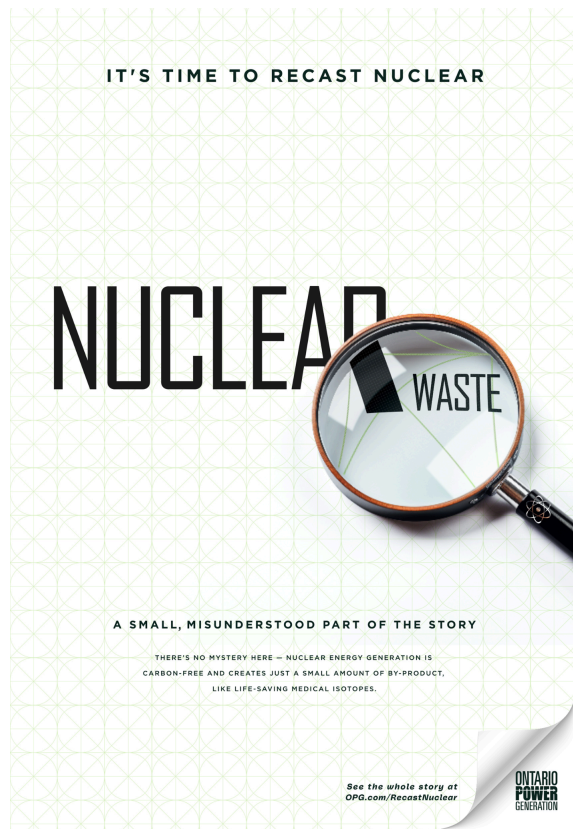


Figure 4.3. An official poster from recast nuclear that was strewn across Ontario, depicting nuclear waste as “small.” *Note.* Screenshot of a campaign poster from *Recast Nuclear* (Ontario Power Generation, 2026).

2. FACT: You receive 200 times more radiation exposure during a cross-Canada flight as you would living next to one of OPG's nuclear stations for a full year (OPG, Accessed 2025).

And...

FACT: OPG's nuclear stations are a vital source of life-saving isotopes like Cobalt 60, which is used to sterilize about 40% of the world's largest single-use medical devices, such as syringes and surgical instruments.

FACT: OPG's Darlington Nuclear will be the world's only commercial power reactor source of Molybdenum-99, a much-needed medical isotope used in more than 30 million procedures a year to detect illnesses like cancer and heart disease.

Rhetorical Tactic: Radiophobia Diminution and Radioisotope Reframing

Size and scale represent one faction of the scope of nuclear fear. The clear other faction, as explored in the previous chapter, is radiophobia. In order to tackle radiophobia OPG uses discourses of quantification to normalize how frequently humans interact with radiation on a day-to-day basis. Instead of shying away from radiation or downplaying its effects, the strategy for the nuclear industry is to educate the public on how radiation is an everyday part of being a human being. Humans encounter radiation daily from a myriad of sources, from food, medical devices, technologies and the sun. If you ever tour a nuclear power plant, the visitor centres frequently display infographics featuring items such as bananas or Brazil nuts, as both foods naturally contain trace amounts of radionuclides alongside their nutritional content. On the U.S. nuclear regulatory commission website, you can even use the annual radiation dose calculator, which calculates your annual radiation exposure using factors such as the elevation you live at, whether you have false teeth, how many miles you travel by plane, and if you have a smoke detector (U.S. Nuclear Regulatory Commission, 2025). Upon completing the calculator, I learned that wearing a luminous wristwatch measured higher on the radiation dose-meter than living

within 50 miles of a nuclear power plant. The point the nuclear industry seeks to emphasize is that outside of rare accident scenarios, routine reactor operation is characterized by high levels of safety and stability. These examples situate quantification as a deliberate response to radiophobia, reframing radiation not as an exceptional threat but as a familiar and measurable component of everyday life.

The strategy of governing radiophobia through normalization has historical roots. Recent research by Rice & Rice (2015) uncovered that during the famed Nevada nuclear weapons tests, the Atomic Energy Commission (AEC), distributed pamphlets to downwind communities which portrayed radioactive fallout as natural and ubiquitous. As the researchers note, the primary function of this rhetoric was a hegemonic impulse to control the narrative and have community members consent to whatever radiation exposure they may encounter. The strategy of normalizing radiation exposure persisted and is institutionalized within contemporary nuclear governance. This can be observed across the industrial-environmental relationship. For example, in an analysis of discourses used by the battery industry in Finland, industry approaches to concerns over sulfate-rich wastewater exiting battery plants were mainly to argue that it's "naturally occurring," therefore not an issue (Sipinen et al, 2025, p.5). Similarly, on the International Atomic Energy Agencies website, a page is dedicated to "Radiation in Everyday Life." On the routine exposure to ionizing radiation, the page reads, "We are surrounded by naturally-occurring radioactive elements in the soil and stones, and are bathed with cosmic rays entering the earth's atmosphere from outer space" (International Atomic Energy Agency, n.d.). While factually accurate, such rhetoric abstracts radiation from the contexts in which it becomes politically and socially salient, namely, moments of accident or failure. This reflects an attempt at risk attenuation, not in the sense that institutions are concealing radiation as a "hidden hazard"

(Kasperson & Kasperson, 1996), but in that framing radiation as banal outside civilian nuclear energy contexts, also serves to diminish radiation's perceived risk within civilian nuclear energy contexts. This juxtaposition underscores how radiation is rendered mundane in routine discourse, yet reconstituted as an exceptional and urgent risk in the context of nuclear emergency planning.

In the aftermath of a nuclear emergency however, the same strategy is generally utilized. In post-meltdown communications, material diminution of radiation is a valuable discourse. Explored in Chapter 3, radioactive fallout can disperse across national borders, persist in soils, waters, and food chains for decades or longer, and expose populations far removed from the original site of release. Despite this scale, official communications following nuclear accidents often translate contamination into bounded, technical language, emphasizing that exposure levels are “trace amounts,” “localized,” and “below safe limits”. This framing does not negate the physical magnitude of contamination, rather it discursively compresses it, rendering a phenomenon that is more psychologically manageable for an individual. Beyond the material diminution of radioisotopes, the valorization of them for other industries is increasingly becoming a key communication point for the nuclear industry.

The valorization of radioisotopes in day-to-day life is becoming commonplace in the nuclear industry. For example, on the world nuclear associations radiation safety explainer page, they use “radiation is everywhere,” rhetoric to channel into the medical uses of radiation (World Nuclear Association, n.d.). The heavy majority function of a nuclear reactor is energy production, however, they do produce radioisotopes as a byproduct which factor into many aspects of healthcare. Canada in particular has positioned itself as a leader in medical radioisotope production, emphasizing the medical and social benefits derived from reactor-produced radioisotopes. For example, Iodine-131 is used for thyroid condition diagnoses,

Fluorine-18 is used in PET imaging for cancer diagnostics, and Cobalt-60 can be used to sterilize single use medical devices (Centers for Disease Control and Prevention, 2025; Crisan et al., 2022; Canadian Nuclear Association, n.d.). Canada provides 50% of the global supply of Cobalt-60, while simultaneously refining 90% of the global supply (Canadian Nuclear Association, n.d.). Canada also produces around 60% of global Iodine-125, a key isotope for treating tumours (Canadian Nuclear Isotope Council, 2023). Overall, Canada is approved to produce 23 radioisotopes from both its commercial nuclear reactors and research reactors. It is a success story that is touted by Bruce power and OPG alike, and now is factoring into the pro-nuclear energy discourse entering popular culture.

Emphasizing the important role of radioisotopes in medicine is not disingenuous; however, it is important to recognize that these claims perform key discursive work. Recent research by Shevchenko and Calic (n.d.) examines how the public comes to view novel technologies as “legitimate” through a study of nuclear energy. Their findings suggest that legitimacy is rarely grounded in technical merit, but instead emerges through entanglements with adjacent concepts, technologies, policies, and social values. This is highly contextual, as in Canada for example, discourses surrounding small modular reactors (SMRs) are frequently intertwined with narratives of progress in the medical isotope sector. Shevchenko and Calic note that these entanglements with unique local needs enhance the perception that SMRs are desirable (pp.21-22). In this sense, radioisotopes function not only as a genuine public good, but as a powerful symbolic resource through which nuclear energy is framed as benevolent. This has precedence, as during the early cold war, the U.S. used the production and distribution of radioisotopes as a way to signal peaceful applications of atomic energy. This in turn was meant as a distraction from the amount of raw materials the government was consuming at the time for

their nascent atomic weapons programs (Creager, 2013; Hamblin 2021). The recast campaign's use of quantification here is not to obfuscate, but to render radiation measurable and non-threatening, while elevating radioisotopes as a representation of the industry at large and national well-being. Risk perceptions of nuclear energy and health are recast, introducing nuclear energy as a “medical superhero,” seen in figure 4.3.

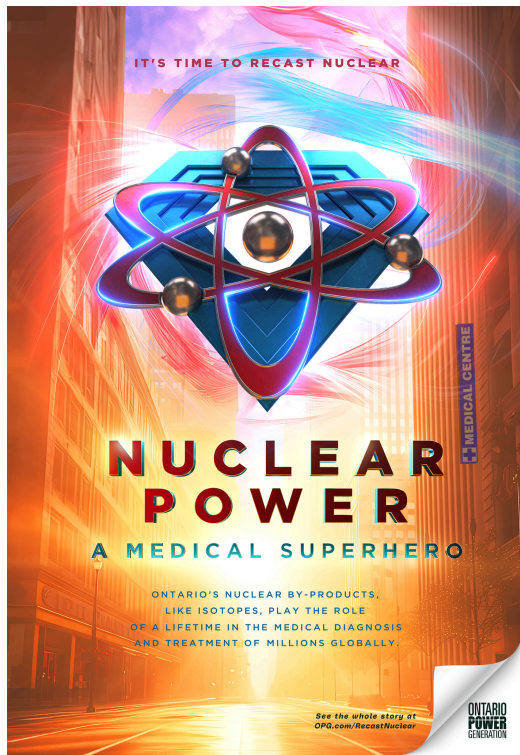


Figure 4.4. An official poster from recast nuclear, depicting nuclear energy as a medical superhero. *Note.* Screenshot of a campaign poster from *Recast Nuclear* (Ontario Power Generation, 2026).

Nuclear Energy vs Other Energy Sources

3. FACT: Nuclear is the most land-efficient means of clean electricity production, requiring only 2.4 km²/TWh per year, which includes all aspects of production, such as mining and fuel fabrication. By comparison, wind requires a whopping 72 km²/TWh per year and solar requires 37 km²/TWh.

Rhetorical Tactic: Efficiency Enlargement via Material Diminution

In this anecdote, the nuclear industry is casting doubt on the feasibility of an energy grid powered solely by traditional renewable energy by highlighting their land inefficiency. The energy transition over the past two decades has centered on wind and solar as central pillars and valuable additions to the grid, however with skyrocketing energy demands and heavy political and economic investment, OPG is on the front lines of scaling up nuclear power. OPG does have a renewables division which includes wind, hydro, solar and natural gas, suggesting that this particular communication strategy is less about undermining renewables and more about reducing the perceived environmental risk of nuclear energy, through pushing it as a low impact source. This is also reified by the little resistance or opposition to renewable projects. While solar remains a minor contributor to Ontario's electricity grid, wind power accounts for approximately 13% of supply and can reach up to 20% on particularly windy days (Syed, 2022). Recent actions by the provincial government reinforce confidence in renewables: in anticipation of growing demand, Ontario is set to procure an additional 5,000 megawatts of renewable energy by 2034 (Crawley, 2024).

Discourses of quantification here play on the environmental rhetoric of "low-impact." Land efficiency isn't necessarily an attractive statistic, but paired with calls for needing lower human impact in the face of environmental protection and climate change, it is meaningful. Solar

farms, a longstanding boon for the green energy revolution, are facing critique for their encroachment onto the environment. A recent study by Wang et al. (2025) found that Solar farms in developed nations pose a high risk to biodiversity loss and indigenous land encroachment. One such example is California's Genesis Solar Energy Center (GSEC). Completed in 2014, this solar farm underscores the growing tendency to site this energy infrastructure in the desert, where the arid climate and low competing land uses are well suited to utility scale generation. The assumption that deserts are "lifeless" obscures the ecological harm of solar farms and reinforces colonial legacies, as projects like GSEC disrupt thousands of native species and proceed without meaningful consultation on Mojave, Chemehuevi, Hopi, and Navajo lands. (Dunlap et al., 2025; Sovacool et al., 2025). This is not an argument that solar energy is not without benefit, nor sunny locations shouldn't use their climate to produce this energy, but rather the nuclear industry is using these land use discourses to scale itself against sources which are framed as environmentally benign, but can carry contested land-use footprints.

This also brings in the necessary discussion of why land use is a valuable quantification currently for the nuclear industry. The answer lies in the heavy investment and elevation of Small Modular Reactors (SMRs), which are pitched as the solution to small communities energy needs, remote mining sites, and power sources for crude oil extraction in the Alberta oil sands. Small Modular Reactors (SMRs), are compact, factory-built nuclear reactors (rather than on-site), prized to be extremely malleable in deployment, and have enhanced safety standards. While they top out at around 1/3rd the generating capacity of a conventional reactor, the ease of construction is supposed to reduce cost and build times, launching a new nuclear era of flexibility, grid reliability and efficiency. Conceptually, modularity is less about size or ease of production, and

more about democratizing the nuclear reactor. In his article, *Do Artifacts Have Politics?* (1980), Langdon Winner distinguishes between authoritarian and democratic technologies. He uses nuclear and solar energy as material examples: nuclear power is inherently authoritarian because it demands centralized control, technical expertise, and hierarchical management. These conditions are necessitated by its design, not imposed from outside forces, hence why it is afforded by the technology. By contrast, solar power affords decentralization and egalitarian access. Through SMRs, the nuclear industry is attempting to reframe nuclear technology as modular, flexible, and locally deployable. The financial commitment to SMR development reinforces this.

SMR's emerged as a cornerstone for Canada's net zero policy. The federally administered SMR action plan outlines plans to invest in and build out SMR's across Canada, with the latest report detailing nearly 100 million dollars in funding for the development of 3 different reactor designs (Natural Resources Canada, 2022). The two provinces which seem to be spearheading the call for SMR's are Ontario and Saskatchewan, who are working together to develop the nascent technology, with the federal government committing 74 million dollars specifically to build an SMR in Saskatchewan (Quon, 2023). In the United States, the department of energy has invested over 600 million dollars over the last decade to help fund and deploy the NuScale Power SMR, which is set to be operational by 2029 (U.S. Department of Energy, n.d.). SMRs are framed as valuable for their efficiency and compact land footprint, and are positioned as a replacement for the energy services currently provided by diesel generators. According to the Pembina Institute, 70% of remote communities in Canada rely on diesel generators to provide electricity, the other 30% made up by fossil fuels or hydro (Heerama & Lovekin, 2019). The

issue is that as energy demands increase, the amount of diesel being burned is not actually decreasing. The nuclear industry sees remote communities as a necessary benefactor of SMRs and microreactors.

Sovacool and Ramana (2015) critique the promotion of SMRs as functions of rhetorical visions of the future, often baked in with discourses of utopia, harkening back to the utopian ideals that nuclear energy evoked in the 1950's. They claim that utopia is invoked through promises of environmental salvation, risk-free energy, and indigenous self-energization, even as fundamental questions of economic feasibility and material constraint remain unresolved. In this way, SMRs function more as a rhetorical device than a technical innovation. While this critique is fair in relation to the history of nuclear energy risk communication, SMRs are more than speculative, and are actually being developed and implemented. The language of SMRs is where issues lie, as they were initially projected as a salve for remote communities, off-grid regions, and isolated infrastructure sites. Yet, in practice, most proposed SMR deployments are now concentrated in energy-intensive, grid-connected urban regions, where electricity demand is high and the energy infrastructure already exists. To follow through on rhetoric of efficiency and material diminution, the nuclear energy industry needs to follow through on the initial promises of this nascent technology. Land use as a quantification then operates as a discursive battleground, where claims of nuclear efficiency can scale against the efficiency of renewable energy sources.

4. FACT: By displacing dirty energy sources such as coal, nuclear power helps avoid about 2.2 billion tonnes of CO₂ emissions annually. That's the same as taking about a third of all the world's cars off the road.

and...

FACT: In Canada alone, nuclear energy helps avoid 80 million tonnes of CO₂ emissions per year. That's roughly the equivalent of taking 15 million passenger vehicles off the road.

Rhetorical Tactic: Environmental Boon via CO₂ Diminution

This discourse of quantification, where the recast campaign scales nuclear energy against gas powered cars, pushes a key reality as to why nuclear energy remains viable considering its history with respect to risk; emissions free production. Discourses of quantification here attempt to construct a binary between “dirty” and “clean” energy sources (such as coal versus nuclear power), by rendering carbon emissions more tangible, through translating CO₂ into familiar comparisons. What is clear through these facts, is an attempt to capture the sentiment throughout energy politics that being categorized as “emission free,” endows nuclear energy with certain benevolent qualities. Garud et al. (2010) write that nuclear energy came to be categorized as an emissions-free source in tandem with the growing prominence of climate change in public discourse. They claim, “By extension, not only did CO₂ begin to count in the wider energy field, there was now a calculative apparatus against which to measure progress” (p.27). Through the new valuation of this quantification, nuclear power is able to recast itself from environmental destroyer to environmental boon.

Several studies have explored the role of nuclear energy in reducing reliance on fossil fuels (Ozturk, 2017; Saidi and Ben Mbarek, 2016), however there are other studies which cast doubt on nuclear energy as environmental saviour, citing ecological footprint concerns such as

deforestation, construction emissions and air quality (Soto & Martinez-Cobas, 2024) and the tendency to engage in resource intensive activities which higher baseloads of “clean” energy (Freire-Gonzalez, 2021). Conversely, new research has highlighted that a growing number of individuals who view climate change as a problem are more likely than those who do not to perceive a new nuclear power as beneficial, even when a proposed facility was located nearby (Seo & Rhee, 2026). It is clear then that there is value in the discursive arrangement of CO₂ reduction, however, the recast campaign uses discourses of carbon *removal*, which is a much stronger metaphor in climate change communications. Beyond the technological application of carbon capture, Castree (2020) cites the rise in Carbon removal discourses is partially to do with failures in meeting the 1.5 degree goal set at the Paris Agreement in 2015. While implementing nuclear power does not take carbon out of the atmosphere, the anecdote associates nuclear energy with a growing movement in policy and public discourse of carbon removal (Jaschke & Biermann 2022; Losi et al., 2025).

The use of cars as mediator in this discourse of quantification is not random. While there is no correlation between nuclear power development and a reduction in passenger vehicles, these discourses simultaneously reify nuclear energy as an environmental boon, while assuaging individual apathy towards action on their CO₂ emissions. Scholars who have studied the public perception of climate change note that there is often an impasse for the general public when considering the connection between CO₂ and climate change (Seacrest et al., 2000). This in turn leads to confusion around how one can reduce their CO₂ emissions, and leads them to question the impact that their personal actions may have, which leads to a lack of action on how to address climate change (Plotnikoff et al., 2004; Etkin & Ho, 2007). Using cars makes an abstract

quantification tangible, and informs the public that individual action on climate change can be distilled into supporting the nuclear industry. In an analysis of excess energy consumers in the U.K., Cass et al. (2023) identify a number of discourses which reify the status quo for individuals with larger carbon footprints. The recast campaign's use of cars as a quantification for nuclear energy's CO₂ emission impact underscores the use of techno-optimism and appeals to psychological values of apathy. In terms of techno-optimism, these discourses push "non-transformative" solutions, such as reliance on future technologies, and delaying present action (Lamb et al., 2020). In terms of apathy, these discourses highlight the tendency for individuals to be inactive by downplaying their ability to make change (Barr, 2006).

In this way, the car functions as a discursive proxy that translates climate responsibility away from behavioural change and toward nuclear energy endorsement, reinforcing a vision of decarbonization that preserves existing patterns of behaviour and consumption. I reach these conclusions, as the comparison to coal can only function as a juxtaposition between “clean” and “dirty,” rather than a legitimate comparable. Electricity production from coal power was a mere 2.9% in 2024, and Ontario closed its last coal fired plant in 2014 (International Energy Agency, n.d.; Ontario Power Generation, 2024). Coal is no longer a legitimate competitor for nuclear energy, however comparing the two while using the metaphor of carbon removal, not only reifies nuclear energy as the clean choice, but reinforces apathetic and techno-optimistic visions of progress in the context of climate change.

Conclusion: Quantifying for the future

The recast campaign uses various discourses of quantification to improve its rhetorical standing against the backdrop of nuclear histories and in comparison with alternative energy sources. While not directly using quantification, this campaign signals its purpose through one more “fact.”

5. FACT: Clean nuclear power will help OPG electrify life in one generation by powering more facets of life, including transportation, homes, and industries (OPG, Accessed 2025).

Rhetorical Tactic: Linking Nuclear Energy with the Future & Progress

If almost a return to the first discoveries of radiation, the valorization of the atom, and atomic energy one day being “too cheap to meter,” nuclear energy is inundated with discourses of progress. While once presented as an autonomous force of good and innovation, new nuclear is attaching to other forward thinking technologies. In the realm of AI, multiple tech companies have announced partnerships with nuclear energy companies in an effort to power A.I. data centers. All the big tech firms have announced strategic partnerships with nuclear energy companies to power their fleet of energy intensive data centres. For example, Constellation Energy is restarting one of the units at TMI in partnership with Microsoft, Alphabet has partnered with multiple companies including Kairos Power, to deploy multiple advanced nuclear reactors, and Amazon is heavily invested in X energy to deploy a fleet of SMRs (World Nuclear News, 2024; Kairos Power, 2024; X Energy 2024). The linkage with A.I. utilizes the same discourses presented throughout this chapter to promote nuclear energy’s capability of meeting this energy intensive moment.

In an article for *Nature* on the potential for nuclear energy to expand to meet A.I. demands, the argument for divestment from fossil fuels remains a central point of support, despite the increased viability and low competing costs of renewables (Castelvecchi, 2024). SMRs are the focal point for these A.I. companies, and mimic the same aspirational musings of a past nuclear moment. In the Ontario Government's ambitious electrification plans, nuclear power is pushed as the source which can take on the brunt of future energy needs, attaching its potential to the sheer amount of power needed to fuel a future fleet of E.Vs. These discourses reflect what Chen (2023) describes as progressive extractivism. While not pushed through LNG expansion, the nuclear industry reifies these discourses through using progressive rhetoric to simultaneously sell sustainability and resource driven economic growth. The nuclear industry is not in the business of environmental sustainability, rather it is in the business of framing nuclear energy as sustainable, and rhetorically attaches to industries which require immense amounts of energy.

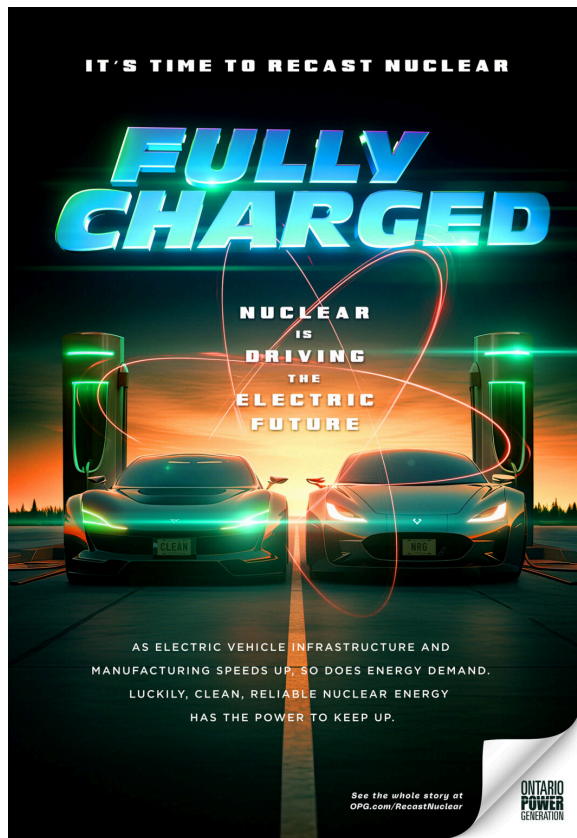


Figure 4.5. An official poster from recast nuclear, depicting how nuclear energy is a boon for electric vehicles. *Note.* Screenshot of a campaign poster from *Recast Nuclear* (Ontario Power Generation, 2026).

Discourses which project temporally into future progressive visions first have to contend with the past. This chapter has shown that the Recast Nuclear campaign operates through a coordinated set of discourses of quantification and scale to reconfigure nuclear energy's past and present relationship to risk and legitimacy. Rather than directly confronting the historical, cultural, and political baggage associated with nuclear power, the campaign seeks to reorder perception by translating nuclear energy into numbers that appear familiar, manageable, and comparable. In doing so, quantification functions not as neutral measurement, but as a rhetorical technology that structures how risk is perceived and rendered acceptable. Across the campaign, strategies of material diminution shrink nuclear energy's perceived threat by anchoring it to

everyday objects such as soda cans, fireplace logs, and gummy bears, while strategies of efficiency enlargement expand nuclear energy's perceived benefit through scalar comparison. These techniques do not deny nuclear risk outright, instead, they compress it, making nuclear energy appear controllable. This suggests a broader shift in nuclear risk communication away from binaries of apocalypse and salvation, toward a numerical logic in which acceptability is determined through comparison.

Quantification also enables nuclear energy to be repositioned within contemporary energy politics. By scaling nuclear power against land use, emissions, and energy efficiency, the campaign reframes nuclear power as a rational response to escalating energy demand and climate change. In this framing, nuclear energy's legitimacy is no longer derived from grand narratives of atomic progress, but from its utility within new national and provincial policy directives. The Recast Nuclear campaign demonstrates how quantification operates as a governing logic of contemporary nuclear energy communication. Using this as a basis for contemporary nuclear energy communications, the next chapter uses the case study of the proposed deep geological repository to house Canada's nuclear waste to build on themes of techno-optimism, and the temporal reorientation of nuclear energy potential.

Chapter 5

No Nuke Dump: The Conflicting Socio-Technical Imaginaries at the Center of Canada's Nuclear Waste Solution

Introduction

On October 28, 2024, after a tense week-long voting period, the municipality of South Bruce, Ontario, narrowly voted to approve the construction of a deep geological repository to house Canada's nuclear waste. South Bruce, a small 500 square kilometer rectangle in the middle of south west Ontario, boasts a handful of country roads, a few small towns, and a population of a little over 5000 people. When driving through South Bruce, two features stand out immediately. The first is the pastoral landscape. Tree lined properties give way to expansive farms, with barns proudly donning a family name which has toiled the land for generations. It is beautiful and variable, cash crops quickly shift to dairy farms, and to fruit and vegetable fields. The second feature which stands out is hand painted yellow signs everywhere, all with different messages. Some have a skull and crossbones and a radura symbol, some say “no nuke dump”, and many have a political message of resistance against the “NWMO.” This chapter analyses this resistance, and the conflict at the center of a community on the verge of accepting thousands of tons of nuclear waste.

Formed by way of policy in 2002, the Nuclear Waste Management Organization (NWMO) is the group tasked with disposing of Canada's nuclear waste. Current scientific and engineering consensus believe that burying waste in a Deep Geological Repository (DGR) is currently the best practice for long term nuclear waste disposal (Feiveson et al., 2011), hence the directive for the NWMO to find a host community for Canada's new DGR. The search for a host narrowed recently to two communities in Ontario; Ignace and South Bruce. Luckily for those

opposed to the DGR in South Bruce, Ignace and the Wabigoon Lake Ojibway Nation also voted to approve the DGR, and were officially chosen as hosts in December of 2024. This chapter draws on qualitative research conducted in South Bruce prior to the final hosting decision; as such, the interviews and community analysis are situated at a moment when South Bruce was still actively contending to host the project.

In this chapter, I argue that the tensions underlying the proposed DGR in South Bruce are due to conflicting socio-technical imaginaries, especially pertaining to the cultural and economic dimensions of the community. Illustrated by Jasanoff & Kim (2015), socio-technical imaginaries are future-oriented, socially constructed visions of technological progress, often held by different groups. The outlined tension in this chapter is between the NWMO and South Bruce. The NWMO envisions South Bruce as a subsidiary of Bruce County, a benefactor of the nuclear energy industry, and a community primed for economic development and nuclear waste innovation. On the other hand, members of the community of South Bruce are farmers first, and view their community as an intergenerational farming success story, anchored by the dairy industry. The broader imaginary at play here is that via hosting a DGR, nuclear waste can be an economic saviour, and poses no serious risks to the community in question. These conflicting socio-technical imaginaries are informed in this chapter through long form qualitative interviews with community members, and an analysis of official NWMO materials. This tension is an important area of inquiry because it both builds on and diverges from research about lay/expert divides, epistemic tensions, and socio-technical imaginaries (Wynne, 1989; Bell, 2023). It is also critical as it adds to a growing scholarship dealing with contemporary nuclear waste politics (Cotton, 2017; Ialenti, 2020).

Furthermore, this chapter is part of an important body of literature which illuminates the social and cultural aspects and implications of energy transitions (Jasanoff & Kim, 2013; Szeman & Boyer, 2017). Energy transitions are much more than just swapping fuel sources, it involves the changing of social, economic, and political arrangements (Miller et al., 2013, p.139). Scholars have noted the social implications of energy transitions in the cases such as wind power (Cowell et al., 2011), nuclear power and uranium (Hecht, 1998; 2012), and oil (O'Rourke and Connolly, 2003). Recent policy shifts in Canada have touted the national direction for its energy policy as that of an “energy superpower,” without consideration of what that could mean for the citizens at the front lines of these transitions. The further expansion of nuclear energy as part of a broader net zero commitment has prompted policy efforts to address long-term nuclear waste management, placing communities at the proposed sites of DGRs⁵ at the front lines of the technical, logistical and social hurdles these projects may face.

This chapter also critically analyzes the consent-based rhetorical strategies flooding large scale energy projects. From imposition to consent, the NWMO are not only giving the agency to the communities on whether to accept the DGR, but at the same time are reframing nuclear waste as an economic opportunity should the hosts choose to “opt-in” (Webler & Tuler, 2020). This is a departure from STS critiques of the tendency for organizations to withhold community decision making while negotiating large scale technological projects (Marres, 2012; Batel, 2018). This is also a departure from extractivist politics associated with mining and energy projects, as often these sites are selected because they are located on a deposit of some kind. For the DGR, the

⁵ Plural used here as the NWMO is beginning to site its second DGR for non-Candu fuel (see Nuclear Waste Management Organization, 2025).

NWMO sent out an open call for willing communities interested in hosting the project. Not only did they receive 22 responses, but had to cut the call short after incurring even more interest. This open call impresses agency onto the potential host communities, and treats them as the primary stakeholder in the process. This marks a departure from the secrecy and mystique that characterized early nuclear-era communications, but it still falls short of fully accounting for the motivations of the NWMO, who use economic incentive to soften any risks associated with the DGR.

Previous Studies

Recently, there have been two studies concerning the DGR siting process by the NWMO. Bernauer & Petrone's (2025) research article argues that many indigenous communities have been left out in the siting process. These include those communities which could be exposed to environmental risk due potential to contamination of watersheds or along transportation routes. The researchers argue that the NWMO used "scalar" tactics to propose that they only needed consent from host communities, while ignoring the periphery indigenous groups which will be impacted at different points throughout the DGR construction and operation, representing a colonial siting process (p.8). The other study, by Communications scholar Marissa Bell, is more in line with this chapter, as it focuses on South Bruce before the final decision had been made to construct the DGR in Ignace. Bell argues that the tensions between the NWMO and the local community were "epistemic," building of scholarship which argues that the chasm between experts and lay people represents a deficit model, where higher valuation is placed on scientific knowledge rather than colloquial knowledge (Wynne, 1989; Phillips and Beddoes, 2013; Bell, 2023). While my research uncovers conflicting epistemic visions of risk, I diverge from these studies in my analysis, instead focusing on the socio-technical tension between the community

visions of the local farmers and the technocratic visions of the NWMO. This emerging body of scholarship demonstrates that nuclear waste politics and communications are a ripe area of research, and my analytical divergences only extend attention to the socio-technical configurations of community, energy politics, and risk.

Nuclear Waste, Deep Geological Repositories and the NWMO

It is imperative before continuing to consider the theoretical and material implications of nuclear waste. Nuclear waste according to the nuclear industry is made up of three components. Those are low level waste such as lightly contaminated work clothing, intermediate level waste, such as any metal components or filters used in the reactor, and high level waste, which is spent nuclear fuel (World Nuclear Association, n.d.). High level waste is the type of waste that generates the most concern, as it has the highest concentration of radioactivity. It is also the kind of waste which will be stored in the DGR. For high level waste, the process to get to the point of long term storage in a DGR is fairly long. After removal from a reactor, the spent fuel, which generates high levels of heat as it continually undergoes radioactive decay, spends the next 6-8 years in a special pool of water, designed to both shield radioactivity and cool fuel bundles (Canadian Nuclear Safety Commission, n.d.). After a near decade in these pools, the spent fuel along with intermediate and low level waste, is enclosed in large steel and concrete casks, referred to as dry storage. Dry storage isn't meant to be the long term solution. After around 40 years, the dry casks are cool enough that ideally they'd be moved underground. Before the nuclear industry rallied around deep geological repositories, several solutions thrown out over the years have failed to stick, including propelling nuclear waste into outer space.

On a theoretical level, it is not difficult to see why nuclear waste poses such persistent challenges. Waste itself, as Mary Douglas (1966) famously argues, is “matter out of place,” a category that signals disorder rather than an intrinsic property of the material. Cotton (2017) suggests that nuclear waste is less a technical issue than a political one, shaped by historical legacies of negligence and insufficient foresight that have left the public deeply uneasy about disposal solutions (p. 6). Within this context, deep geological repositories (DGRs) are positioned as an attempt to reconfigure the cultural politics of nuclear waste through reclassification, moving waste from a visibly precarious, above-ground state into a managed underground one. For Douglas, classification is foundational to how societies render the world intelligible, and when an object resists its classification, it becomes threatening (1966, p. 45). Above-ground nuclear waste storage then is symbolically and culturally “out of place,” as scientific consensus dictates that DGRs are the future of nuclear waste storage. DGRs solve both a cultural issue and a temporal one, as the half-lives of the radioisotopes found in spent nuclear fuel induce fear and motivation for long term solutions. Half-lives is a measurement of the time required for radiation to decay to half its initial value. Strontium-90 has a half-life of approximately 30 years, plutonium-239 for roughly 24,000 years, and uranium-235 remains radioactive for hundreds of millions of years. Above ground storage then is seen as temporally irresponsible, and from a risk theory perspective, DGRs reflect the social impetus to manage the projected dangers of the future (Beck, 1992, p.34). Nuclear waste thus becomes emblematic of modern risk society: a material problem whose consequences are deferred across generations, demanding political and cultural responses in the present in the form of deep geological repositories.

In the spirit of this, there is an international effort to license and begin constructing these DGRs. Functionally, a DGR is an isolated site where radioactive materials can decay naturally, unaffected by environmental or geopolitical factors. In that vein, DGRs must be designed in a way in which they are simultaneously easy to seal and forget about forever, and accessible and easy to repair should there be any issues (Piesing, 2024). Storing spent fuel underground is seen as the most sufficient way to address the current environmental concerns of nuclear waste, as the geological stability of bedrock is considered the safest option to shield it from any environmental risks it could impose (Organisation for Economic Co-operation and Development, Nuclear Energy Agency, 2023). Southern Ontario specifically has low seismic activity and stable sedimentary rock, so therefore is a strong candidate for a DGR (Noronha, 2016). As for geopolitical factors, current examples of the vulnerability of above ground storage is at the Zaporizhzhia Nuclear Power Plant in Ukraine, where Russian attacks have damaged the facility and left spent nuclear fuel vulnerable to leakage and exposure (Tobias & Peter, 2022). The qualities of geological permanence and isolation from human conflict make deep geological repositories very compelling in theory, however there is little real-world experience with actually building and operating them successfully.

The lack of precedent across the world presents the first and largest challenge for the NWMO. Most nuclear waste storage sites are either not permanent or not classified as deep geological repositories. The only operational DGR similar to the one proposed in South Bruce is the Waste Isolation Pilot Plant (WIPP), in New Mexico, USA, which stores radioactive materials from nuclear weapons and defense activities. This DGR isn't without issues. In 2014, a container with radioactive waste exploded, resulting in 22 workers being exposed to radiation. An article in

Nature (2014) reporting on the accident concluded concerns espoused by many, “But as with the Fukushima nuclear power plant in Japan, the same characteristic errors were in play: hubris, overconfidence in safety assumptions, dilution or non-respect of safety standards, a weak security culture and, crucially, lack of tough, independent scientific and technical oversight”. The WIPP plant, while offering some economic benefit to the roughly 1700 workers in the area, took around 25 years to site, license, and construct, with community pushback being rife throughout the process (Bowen & Ponangi, 2024). In terms of more contemporary examples specifically designed for spent reactor fuel, only one facility in the world is on the precipice of successfully disposing nuclear waste in a fully constructed DGR, which is the Onkalo spent nuclear fuel repository on the west coast of Finland.



Figure 5.1. An Image taken from the Posiva Website of a Drilled Tunnel in the Nascent Onkalo Spent Nuclear Fuel Facility. *Photo via Posiva Oy. (n.d.).*

Construction on the Onkalo repository broke ground in 2004, and is currently in the trial run phase, where the facility will test their logistical and storage systems with non-radioactive materials (Patel, 2024). The facility expects to begin depositing nuclear waste in the next few years. Outside Finland, the other nation furthest along is Sweden, who is in the construction phase with their DGR. Outside of Scandinavia, Switzerland recently applied for a construction permit for their site, and France has successfully selected a site and is in the regulatory and permitting process. Outside of these nations, the United Kingdom, Germany and Japan are all searching for sites to construct DGR's. Deep geological repositories may be newer infrastructure, but there is consensus among the international community that they are necessary. Interestingly, the United States remains stagnant on this issue. Having selected Yucca Mountain as the preferred site were they to build a DGR all the way back in the 1980s, the impetus to develop plans remain up in the air (El-Showk, 2022). One important development to note is that the countries furthest along in the development of a DGR have passed the responsibility of nuclear waste off to organizations which operate outside their respective governments.

South Bruce

In Canada, the DGR host community is between South Bruce and Ignace, with familiarity with the nuclear energy industry being much higher in the South Bruce. Teeswater, the specific town where the DGR will live, sits half an hour from one of the world's largest nuclear generating stations, Bruce Power. Bruce Power employs over 4000 people in the area. It is a key pillar to the province-wide economy, and everyone who lives in Grey-Bruce knows someone who works at the plant. Despite being so close to the massive nuclear power station, South Bruce's socio-economic livelihood is tied to the dairy industry. In 2016, the county announced an expansion of the South Bruce–Gay Lea partnership, adding \$160 million into the local

dairy-processing sector, strengthening the cornerstone industry for the region (Bayshore News Team, 2016). The official economic and social plan for the county is filled with modest policies to keep its municipalities intact and operational, with the overarching policy commitment reading, “To enhance the function of Formosa, Mildmay and Teeswater as local service centres for the surrounding agricultural community” (Municipality of South Bruce, 2023). Any economic development surrounds either the dairy industry or servicing local residents, and the potential for a county altering project like the DGR threatens to change this.

Finding and approving a site is critical, and the process is generally long and arduous. The world's first DGR for spent fuel at Onkalo, which opened in 2023, began their search in 1983, with community approval coming in 2000. Experts are generally in agreement that while the engineering difficulties are immense (i.e., seismic stability, the right geology, low inhabitation, a site which can support the immense infrastructure), the social hurdles of siting a DGR are equally as complex (Gaffney, 2024). Convincing a host community to agree is partially a communication issue. The NWMO’s efforts with respect to community based siting are an effort to avoid the unkind history of implementing a DGR, exemplified by a number of these sites failing due to a lack of community support (El-Showk, 2022). Yucca Mountain in the United States for example, was embroiled with public backlash, both from the Western Shoshone, whose land the proposed site occupied, and local citizens, activists and politicians. The central reasons for the rejection of the site were environmental justice and indigenous land sovereignty. Houston (2013) argues that the Yucca Mountain DGR is an example of treating a space as a “sacrifice zone,” wherein assumed “undesirable” and often indigenous land is treated as a place to push environmental burdens in the name of national and economic interests (p.420).

This occurred throughout the 1950s and 60s with uranium mining, as the discourses at the time amplified that it was taking place in deeply isolated regions, despite potential toxic threats to local indigenous communities (Hannigan, 1995, p.48). Here in Canada, officials attempted to site a DGR for low and intermediate level waste, but were unsuccessful. In 2020, the town of Kincardine voted to approve a deep geological repository for low and intermediate level waste, however OPG later had to scrap the project after the Saugeen Ojibway Nation overwhelmingly (85% no) voted against it (CBC, 2020). Judging by the indigenous legacies left by nuclear energy, it is not complicated to see why.

Deep Geological Repositories and Communication Strategies

The NWMO was successful in both the South Bruce and Ignace community referendums, however the vote in South Bruce was extremely close. The NWMO used a number of communications strategies to try and get support for this project over the line. The overarching ethos of the communications strategy from the NWMO was the aforementioned community based siting process, with a local economic boost being the central selling point. In an analysis of communication strategies for siting energy infrastructure, Webler & Tuler (2020) find that in Canada, framing these projects via consent is the new norm, because it levels the power between industry and community, and pushes the responsibility for the project onto the community, as they chose to, “opt-in.” This approach rhetorically reifies infrastructure projects as “economic opportunities,” should the locals choose to participate. The big energy suppliers in Ontario, Ontario Power Generation, Hydro One, and Bruce Power, are all extremely involved with their host communities, as friction only complicates the massive agreements that allow big generating stations to operate. In terms of community selection, the NWMO promotes partnership,

environmental protection and “community well-being” (Nuclear Waste Management Organization, n.d.).

Binding the future of South Bruce with the NWMO is the hosting agreement. The hosting agreement between the NWMO and the Municipality of south Bruce is a thick booklet filled with legal parameters should the DGR be set up in town, and plans and maps for the proposed site. Set forth in the hosting agreement are binding concessions the community or the NWMO must make in the case of the approval or rejection of the site. To iterate the tone of the agreement, an example is statement 3.2.2 (a) under section 3.2, Community Willingness and Support. It states that in the case where south bruce approves the project, the municipality shall use its authority to make sure that the community “ does not engage in any action that could frustrate, delay or interfere with, or stop NWMO from proceeding with the project in accordance with the regulatory approvals...”. Not only this, but the rest of the section continues to set forth a relationship whereby the municipality can only engage in supportive behaviors. While community consent based approaches are generally a departure from STS critiques wherein corporate and government stakeholders withhold community decision-making power in large scale technological projects (Marres, 2012; Batel, 2018), the language of the NWMO in the hosting agreement is predicated on frictionless operation once the agreement is signed.

Then there is the quid pro quo of adopting the DGR; the repository comes with a massive injection for the local economies; 418 million dollars for South Bruce, and 169 million dollars for Ignace (Hosting agreement, n.d.). These dollar figures represent the cost of overhauling each community's infrastructure in order to support DGR development. The repository pitched by the NWMO is much more than an underground tunnel. It is a 2km by 3 km underground space between 500 and 800 meters beneath the earth's surface. The complex underground system will

have a labyrinth of placement rooms for the cast concrete waste containers. It'll require boring, blasting and excavating large amounts of rock that will be piled nearby. Above ground, there is a need to construct many facilities including waste packaging plants, settling ponds, material compacting plants and mining shafts. Facility wise, there will be administration buildings and emergency service infrastructure built. The logistical challenge of trucking nuclear waste to the DGR is also a serious consideration. In their 2021 transportation plan, the NWMO puts forth two transportation plans, one truck based and one train based. Truck-only transportation would see 620 shipments per year, nearly twice per day, and would need local road infrastructure upgrades to support the volume. Rail only shipping would see a shipment of nuclear waste every six days to the proposed site, and would need the requisite rail infrastructure in place. In an effort to ensure safety, the containers would undergo a rigorous testing program consisting of drop-tests, puncture tests, becoming engulfed in flames, and tests in pressurized environments (Nuclear Waste Management Organization, 2021). What is clear then is that the economic incentives for each community are more than just labour opportunities, and infrastructure upgrades.

Communicating the DGR also involves reframing nuclear waste and pushing discourses of passivity. First, nuclear waste is not the preferred term for the NWMO, rather throughout their website, used nuclear fuel is the prioritized terminology. When explaining used nuclear fuel, the NWMO mimics OPG, though claims like “Unlike depictions in comic books and movies, used nuclear fuel in Canada is not a liquid or a gas. It is a stable solid - actually a ceramic - sealed into a specially designed container and then bound in a ‘bundle.’ Each bundle weighs about 53 pounds and is roughly the size and shape of a fireplace log (Nuclear Waste Management Organization, 2019).” The fireplace log, while an apt comparison to the sizing of a fuel bundle,

obfuscates the scale and logistical challenge ahead of shipping thousands of tonnes of spent fuel across the province. In terms of passivity, the NWMO wants the residents of South Bruce to recognize the DGR as a final resting place for Canada's nuclear fuel, emphasizing the ultimate goal of closing the facility for monitoring (Hosting Agreement, n.d.). More broadly across industry, The IAEA (International Atomic Energy Agency) uses terminology such as isolation and "passive safety," meaning upon closure, there is no need for human intervention at a DGR (Mikhailova, 2019). Passivity here is used to make the DGR more temporally palatable. The real scope of the project is a 175 year long commitment, from planning to construction to operating and monitoring, ending with the decommissioning phase by the year 2192. The 23 billion dollar project will take 20 years of planning and construction before it is fully operational (Hosting Agreement, n.d.). Despite this, the rhetorical temporal impetus for the NWMO is to project way into the future. The NWMO's official communications do not get into the weeds within the next two hundred years, or the hurdles the project could face in the licensing, construction, or operation phase. Rather their website states, "This responsive and prudent approach is consistent with what Canadians said is required to ensure safe management of the used fuel for tens of thousands of years" (Nuclear Waste Management Organization, n.d.).

One way the NWMO has actively attempted to soften the scope of the project is by hosting a site visit to the Onkalo Spent Nuclear Fuel Facility in Finland, with community and indigenous representatives from each municipality. The Onkalo DGR is contracted by Posiva, who employed similar rhetorical tactics to gain approval from their own host community. Hietala (2021) claims that Posiva's communications were predicated on making the DGR seem more "familiar," via framing the repository as a technological infrastructure rather than a nuclear site.

Additionally, similar to the potential impact of Bruce Power, Posiva leveraged the positive safety record and socioeconomics of the local Olkiluoto Nuclear Power Plant, an employer of many of the local residents (Piesing, 2024). In order to analyze how this communication strategy ultimately landed with local residents in South Bruce, I visited Teeswater, and spoke with a couple farmers directly impacted by the DGR site. I also spoke with the Mayor of South Bruce, to gain an alternative understanding of why the community may need this infrastructure project.

Methodology

Research Design & Approach

This study adopts a qualitative research design, using long-form, semi-structured interviews to explore how the local community responds to the potential for South Bruce to become home for Canada's nuclear waste. The interviews were not designed to be stagnant, rather I developed relationships with two of the participants and toured their homes and farms, gaining a sense of what they believed to be at stake if the DGR were green-lit. Explained in the next section, I selected direct stakeholders in the project for the interviews, in order to craft a compelling narrative surrounding the socio-technical tensions underlying the DGR siting.

Participant Selection & Recruitment

To elicit responses that could build a compelling narrative about South Bruce, it was important to select participants who were direct stakeholders in the project. Before beginning participant selection, I wanted to ensure that one interviewee was someone directly affected by the proposed DGR site itself. This was necessary in order to capture the on-the-ground impacts on a specific farm, including the presence of planned infrastructure, the anticipated movement of

waste transport vehicles, and the possible effects of nuclear “stigma” on the marketability of their agricultural products produced on land immediately adjacent to the site. I also wanted to include a second participant who opposed the DGR and had actively campaigned against it, so that I could better understand the discourses and arguments mobilized in resistance to the NWMO. Finally, the third participant needed to be both pro-DGR and directly connected to the project. This was important not only for understanding the discourses supporting the DGR at the community level, but also for examining how NWMO messaging may be interpreted and rearticulated locally in ways that reinforce support for the project.

I selected participants using purposive sampling, to ensure I spoke to a community member directly affected by the location of the DGR, one community member who generally opposes the DGR, and one community member who supports the DGR. Purposive sampling is a strategy that utilizes intellectual work beforehand in order to select the proper participants who elicit the most value for the research directive (Emmel, 2013, p.51). This intellectual work consisted of speaking with many community members in order to find those who espoused the most concern, and had deep reservations about both the NWMO and the DGR. This led me to two individuals who were repeatedly mentioned, and whose names I’ve changed for anonymity. The first is Maartje, who is responsible for making the yellow signs displayed around the county, found in figures 5.1 and 5.2. The next participant is Cathy, who recently found out that the NWMO has purchased property around her farm as the location to construct the DGR. In order to balance out these two voices, I searched for a willing participant to speak on their support for the project. With little luck in my time spent in South Bruce, I opted to speak to resident and public official, Mark Goetz. Mark is the Mayor of South Bruce and is an authoritative voice on

understanding why roughly half his county is for the project. The ultimate goal of purposive sampling is to present salient representative categories (in my case, pro/anti DGR) of the research, not to statistically represent a population (Mason, 2002).

Data Collection Process

For the Mayor, I conducted the interview over the phone, as he wasn't in town while I was conducting this research. The two residents I spoke with in person, both for over an hour, and took written notes the whole time. Those notes informed my descriptions of each interaction, and my analysis of the project as a whole. I toured the resident's farms, grounding a better understanding of what is at stake in the negotiations on approving the DGR.

Data Analysis

I compiled the notes from the interviews and synthesized them into the "Interviews" section below. These interviews inform further analysis within this chapter of the tensions between the locals and the NWMO. This research uses narrative analysis which interprets stories and lived experience as the primary tool to inform my broader inquiry into the community politics of the DGR. The point of this approach is to treat the residents of South Bruce as active agents, rather than passive subjects, in the negotiations between the NWMO, South Bruce and the DGR. Part of narrative analysis is an appreciation for phenomenological approaches which are centered on lived experience and everyday knowledge as sources for scientific inquiry. This inspired a generation of philosophers such as Heidegger and Merleau-Ponty, and many STS scholars, exemplified through the turn to laboratory studies where Latour and Woolgar (1979), centered situated knowledge and everyday practice as key objects of study. More so, the research merged epistemological reasoning with ontological positioning. This was done intentionally, as

previous research on this case has focused on epistemic tensions (Bell, 2023), without concern with ontological situatedness in research (van Heur et al., 2013). The analysis of my data considers fracturing along the lines of both epistemology, and ontology, more specifically the chasms between world view of the NWMO technocrats and the lived experience of farmers.

The situated nature of my research also put me in the position of the farmers, who often do not have the luxury of time to step away from their daily work to speak with others. While I spoke with both Maartje and Cathy, their focus remained on making sure the cows and sheep that needed to be milked were being cared for, and the rest of the farm was operating as it should. While I was speaking with Cathy, a sheep went into labor and the lamb became stuck during delivery. Our conversation paused as she called over her husband, who intervened and successfully delivered the lamb alive. These moments underscore the importance of reflexivity in research: while I can enter a community and capture a snapshot of local nuclear waste politics, the implications for community transformations brought on by large-scale infrastructure are far more extensive.

Ethical Considerations

It is important to acknowledge that the Saugeen Ojibway Nation, Chippewas of Nawash Unceded First Nation, and Wabigoon Lake Ojibway nation are direct stakeholders in the development of the DGR. This research does not involve direct engagement with Indigenous communities or individuals. That choice is both methodological and ethical. Under Canada's *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2)*, research involving Indigenous peoples (Chapter 9) requires community level engagement and

co-developed research agreements that reflect Indigenous self-determination and data sovereignty. Undertaking that kind of work requires a much more detailed research process that I believe falls outside the scope of this chapter. Ethically, rather than risk misrepresentation or colonial frameworks, this research analyzes some publicly available materials produced by Indigenous organizations, as well as media coverage and scholarly work that underscore the connection between Indigenous communities and nuclear waste governance.

For the interviews that were conducted, informed consent was treated as an ongoing process, consistent with TCPS 2 principles of respect for persons and voluntary participation. Participants were provided with written consent forms prior to participation and were informed of their right to decline questions, withdraw their statements, or request the removal of their data at any time. After offering, two participants elected to remain anonymous; one participant, Mayor Mark Goetz, was interviewed in his public and professional capacity and is therefore identified. Due to the scale of the research location, and the tight-knit nature of small communities, complete anonymity cannot be guaranteed, which participants were informed of prior to obtaining consent. I did not record the interviews, but any written notes taken during the interviews are to be destroyed following the release of this chapter. For the presentation of the interviews, I produced narrative descriptions and in my descriptions, I avoided distortion, sensationalism, or selective quotation. This is an effort to represent participants' perspectives as contextually true as possible. I am positioned with interpretive power through the use of participants' own words to represent my findings, and vow to be responsible with this, first and foremost through giving the participants to opt out at any time throughout the research and writing process.

Limitations

To reiterate, this is a snapshot of an analysis of a few residents' opinions on the NWMO's community based siting process for the purposes of implementing a deep geological repository. This is not representative of the whole community, nor the Saugeen Ojibway Nation, Chippewas of Nawash Unceded First Nation, or Wabigoon Lake Ojibway Nation.

Interviews

Mayor Mark Goetz

Mark Goetz is the Mayor of the Municipality of South Bruce and has been involved in the deep geological repository (DGR) project since 2014. He has participated in every significant meeting and helped negotiate the hosting agreement, which will pay the community \$418 million over the next 138 years. Mark is both confident in the science behind the DGR and the NWMOs approach. He believes the odds it ends up in South Bruce stands at 50/50 with the other proposed site in Ignace, Ontario. Beyond his own community, Mark is concerned about the nuclear waste currently sitting above ground in Canada, comparing it to the unaddressed disposal of electric car batteries, and believes it is crucial to develop a long-term plan for future generations. Mark told me he is awaiting the results of the referendum in early October to determine community approval, but even with approval, he knows that the NWMO cannot proceed without the consent of the Saugeen Ojibway Nation and the Chippewas of Nawash Unceded First Nation.

Mark supports the project mainly due to the economic benefits that come with it. In our conversation, he reminisced about when he was a kid, and South Bruce was thriving. He mentioned that schools were filled and small family farms were abundant. Mark has noticed that

over the past decade, declining school attendance and the consolidation of small farms into larger enterprises have threatened the community's viability. According to Mark, the situation can only improve with the NWMO's involvement. He claims the DGR offers opportunities for non-farming jobs and allows smaller family farms to be supplementary sources of income. In Mark's eyes, the proposed DGR is just what Teeswater, and the broader county of South Bruce, need. Addressing concerns from farmers about potential loss of market due to the DGR, Mark cites farms around Bruce Power that have had no issues selling their products. As a beef farmer with 100 head of cattle, he emphasizes the hosting agreement's clause to compensate farmers for any financial losses, and the property value protection plan to ensure fair market value for their land if they find the situation untenable. He also reminded me that the NWMO has invested in local schools, medical clinics, and other community infrastructure, which will continue regardless of whether the DGR is built in South Bruce or Ignace. Mark welcomes resistance to the project and has allocated four seats for anti-DGR community members on the delegation to Norway to see the Onkalo site. In our conversation, Mark brought up one of those concerned groups, Protect Our Waterways, and their main worry of potential aquifer contamination. Mark explains that the boreholes testing the rock for the DGR are 640 meters deep, while aquifers are at 60 feet deep. He notes that mines often bore past aquifers without issues and that the moisture at the proposed DGR site has high salinity and therefore is not part of the aquifer water. Overall Mark is bullish on the project, and hopes his community votes to approve the DGR.

Cathy

Cathy and her husband bought their farm 30 years ago, when there was barely anything on the land, much less an operational business. With the help of their infant children, they built barns to house sheep for milk and meat, and to house beef cattle. Now, their livestock include 70

cows and 350 sheep. The sheep are especially productive in eliciting dairy, as they can be milked 16 at a time, producing 2-3 liters each. In addition to livestock, they grow wheat and bale hay for other farms. Cathy and her husband work hard, beginning their days around 4:30-5 AM and finishing around 7:30-8 PM, only taking Sundays “off.” Off is in quotations as Cathy tells me on days off, they still work around 8 hours. Cathy is saddened when she tells me that her daughter, son-in-law, and their three children will not move back to Teeswater should the planned DGR move forward. She emphasizes that farming requires foresight, needing to plan years ahead before planting a crop. The uncertainty caused by the DGR makes it increasingly difficult for her to envision a future for herself and her children in farming. Cathy laments the assumption that small-scale farming is no longer economically viable, an assumption supported by the Mayor. She cites her and Maartje’s (next interview) successful farming operations to contradict this belief.

Cathy only learned about the plans to build a deep geological repository (DGR) in South Bruce in 2019, despite discussions dating back to 2012. In early 2020, she attended a sparsely attended community meeting where she was informed that the site for the DGR was still undecided. The next day, she discovered that the Nuclear Waste Management Organization (NWMO) had purchased around 1700 acres of farmland surrounding her property, which left her surprised, shocked, and upset by the lack of transparency. She then created a homemade map of the NWMO's land purchases and distributed it in town, leading to a much larger turnout at the next community meeting, where people were equally confused and upset. Cathy found the tone of the community meetings frustrating, with little time for questions, and responses that deflected or silenced concerns. When allowed to present, she had to submit her presentation to the NWMO beforehand, which she felt was an attempt to censor her. Cathy's main concern, apart from her

family's future, is the water supply. She points out that even in New Mexico, where the only operational DGR is located far from any community, there was an incident where workers were exposed to radiation. She fears groundwater contamination and notes that any change in water quality could deter her cows and sheep from drinking it. Some of her direct customers, such as butchers and wholesalers, have also expressed that they would look elsewhere for products if the DGR is built.

Along with the DGR, Cathy mentions plans for a settling pond and a repacking plant, where nuclear fuel waste would be repackaged before storage. She is also concerned about a 65-acre rock pile from borehole blasting, claiming it could contain radon. Although the NWMO claims safe exposure levels for all aspects of the project, Cathy questions how many "safe" levels one can be exposed to before they become unsafe. She distrusts the NWMO, Ontario Power Generation (OPG), and the Canadian Nuclear Safety Commission (CNSC), citing issues in Chalk River⁶, Peterborough⁷, and Elliot Lake.⁸ The NWMO is supposed to decide later this year whether to place the DGR in South Bruce, but Cathy doubts it will proceed due to rumours about lack of approval from the indigenous community. Cathy also discusses the claims made about successful farming operations in the vicinity of Bruce Power, and highlights that Bruce Power

⁶ In the 1950's, two accidents occurred at the Chalk River Laboratories, north west of Ottawa, Canada. In 1952, the NRX (National Research Experimental) reactor on site melted down, causing a radioactive pool to form. This was the world's first reactor meltdown, and was a very serious meltdown compared to others in history. In 1958, the NRU (National Research Experimental) reactor was undergoing repairs when a jammed fuel rod broke, caught fire, and expelled radioactive dust. The two accidents were crucial in design considerations for the CANDU reactor, which is still operational today (Guillemette, 2023).

⁷ Citizens in the city of Peterborough, Ontario, are concerned about air quality levels due to beryllium emissions from a nuclear energy facility. The Canadian Nuclear Safety Commission (CNSC) measured and continues to monitor emissions from the facility, claiming that the beryllium levels are safe for human exposure (Davis, 2024).

⁸ There are ongoing fights between homeowners and the CNSC over who is responsible for cleaning up nuclear waste left behind at the Elliot Lake uranium mining sites. In this former uranium mining hotbed, radioactive rock was used as fill during the decommissioning process, leading to higher levels of radiation emitting from the ground upon which homes stand. A judge recently ruled in favour of the CNSC, claiming that it was not responsible for removing the radioactive rock, as it is only responsible for radiation emitting from nuclear energy production or development, not naturally occurring substances (Migneault, 2023; Rutherford 2025).

occupies almost 2000 acres and doesn't have any large farms close by, unlike Teeswater. The closest dairy farm to Bruce Power is 11 kilometers away, she claims. Cathy observes that the community has suffered due to the DGR issue, with neighbors afraid to upset each other over their opinions, and families splitting over the differences on the project. She credits her religious faith with helping her stay sane over the last few years with the prospect of overwhelming change to her community.

Maartje

Maartje moved to Canada from Holland 27 years ago, driven by the need for more land and the rising cost of food production. A friend who had already relocated convinced her and her husband to explore South Bruce as a potential home, leading to their decision to move. They now operate a 1500-acre dairy farm with 500 cows, yielding an average of 35 liters of milk per milking per cow. Their farm is a closed-loop system, growing all the feed for the cows and using the manure as fertilizer for their crops. Maartje and her husband are deeply concerned about the proposed deep geological repository (DGR) by the Nuclear Waste Management Organization (NWMO) for storing Canada's nuclear waste. Their concerns stem from their experiences with the Chernobyl disaster and its lingering effects. She is from northern Holland, where the Chernobyl radioactive cloud passed over, affecting the country's livestock. Maartje also tells me about Chernobyl causing radioactive Bavarian wild boars⁹, and deformed children in Romania¹⁰. Maartje is especially sensitive to health effects from radiation as she herself had to have her thyroid removed due to a genetic form of cancer.

⁹ While wild boars in Bavaria do have increased levels of radiation via feeding on radioactive truffles, the source is disputed, as scientists suggest that the Boars were dosed after a nuclear weapons explosion in the 1960s (Patel, 2023).

¹⁰ As for the Romanian children, I couldn't find any sources on deformation, however there are studies which show increases in thyroid cancer instances in Romania post Chernobyl (e.g. Gabora et al., 2018).

Despite the NWMO's financial investments in the local community, such as new fire trucks, school funding, and bursaries for students, Maartje remains vehemently opposed to the DGR. She has actively spoken out against the project, even facing expulsion from a business association meeting for her stance. She criticizes the local council for promoting the DGR without adequately informing residents, and alleges that the county government is biased in favor of the project. Maartje distrusts the promises of economic benefits, fearing that the risks are being downplayed. Additionally, she fears that to cover the DGR's \$26 billion dollar cost, the NWMO might begin accepting nuclear waste from other countries. Her main risk concerns include potential contamination of aquifers, which could impact products from her dairy used by Gay Lea and Chapman's Ice Cream, the latter of which coincidentally opposes the DGR. Maartje claims there is a propaganda machine at work, falsely portraying the area as economically depressed and in need of the DGR. She worries about the integrity of the upcoming digital referendum vote on the DGR and distrusts local elections, believing that those in power could impact the results to approve the DGR. Maartje is frustrated by her neighbors' silence despite knowing that many privately oppose the project. To combat the DGR, she started making bright yellow signs with various messages three and a half years ago, which now populate the region.

Signs

The signs that are littered all over South Bruce are the brainchild of Maartje, who has a workshop at her dairy farm. The little room filled with paint, brushes, plywood and old signs is the basis of the aesthetic resistance that exists within the community. Maartje's signs are noticeable not just because of their bright yellow colour, but also their use of unique messaging, and radio-iconography. Radura symbols, skulls and crossbones, and discourses of permanence, toxicity and pollution permeate the fleet of signage around the community. One specifically

powerful sign is on the drive into Teeswater from the North end of town, which reads “Welcome to Nukewater.”



Figure 5.2



Figure 5.3

As seen in figure 5.2, the workshop is well equipped with supply's, more signage ready to be put up and even options for the Christmas season. One of the starkest juxtapositions I witnessed while in Teeswater was a big white sign put up by the NWMO reading, "Initial Borehole Drilling and Testing," among a fleet of yellow signs pushing resistance to the project.

Analysis

The interviews I conducted in South Bruce represent a chasm between the technocratic visions of the NWMO and Mayor Mark Goetz, and the community based mentality of Maartje and Cathy. Bell (2023) argues that the knowledge of the community members in South Bruce isn't valued, leaving an epistemic divide, however my experience within these communities renders that analysis slightly reductive. This is not to say that Maartje and Cathy didn't raise concerns about the feasibility and safety of the DGR that were discounted and downplayed by the NWMO. Both raised issues with water contamination, and cited past events which legitimize their fears which were either ignored or silenced. My contention rather, is that these concerns and my understanding of the community, was that above all else, a rejection of a new technocratic order, wherein the DGR became the new economic and cultural focal point of South Bruce. The NWMO then represents a threat to their agrarian way of life, and the likelihood that their family continues the operation of their family farms. As seen with Cathy's comments on water contamination, her primary concern was that her livestock would refrain from hydrating if they noticed a change in the water's taste. This anecdote, and my interviews represent a tension between techno-optimist accounts that deem the DGR is a saviour for an economically starved community, and community members, who despite some struggles, see value in keeping the socio-economic fabric of the locale intact. Simply put, the DGR threatens Maartje and Cathy's ontological reality and future, while simultaneously being told that approving the DGR is a better way forward.

Mayor Mark, the NWMO, and Techno-optimism

In South Bruce, the prospect of hosting a deep geological repository is positioned as an opportunity for socio-economic renewal. The NWMO and Mayor Mark Goetz both frame community progress in terms of improving the socio-economics of the local community. This is not to say that throughout my interview with Mark he did not raise genuine concerns about above ground nuclear waste storage. Many experts argue that the way nuclear waste is currently stored is unsustainable. Rather his notion that South Bruce needs a DGR is not rooted in responsible storage, rather it is rooted in socio-economics. Mark's concerns are reified by economic and census data; South Bruce has an aging, undiversified population. Census data from 2021 points to a median age of 46.3 in the county, with a large reliance on agriculture for income (Statistics Canada, 2022; Municipality of South Bruce, n.d.). The future of the local economy in large part depends on youth retention and diversifying the labour opportunities in the area. According to this data, Mark is simply doing his job as the Mayor, and is completely justified in his concerns about the future of his community. For Mark, a DGR not only brings in jobs specific to the build site, but also requires labour for new services, which creates new customers for local businesses. Interestingly, the township of Ignace shares a similar outlook, according to research conducted by the NWMO. The population is shrinking at quite a high rate, 35% down between 2001 to 2016, and the unemployment rate is high compared to the rest of the province. The housing report is especially dire; around 22% of dwellings require major repairs (Nuclear Waste Management Organization, 2023).

While the economics of South Bruce and Ignace may be in need of an injection, the belief that the DGR will be a miracle fix for these communities is part of a larger socio-technical imaginary which presents economic benefits under the guise of fulfilling large-scale technological projects. Socio-technical imaginaries (STI), write Jasanoff & Kim (2015), are ways in which the aims of science and technology weave their way in the social, material and moral aspects of life (p.3). In this vein, Mark's pining for the community of his youth is imbuing the DGR with a social and moral responsibility of returning South Bruce to some nebulous form of former glory. While economic opportunities are often byproducts of large infrastructure projects, the focus of the NWMO is not on Teeswater's generations of farmers and farming legacy, but on fulfilling the goals of Canada's Policy for Radioactive Waste Management and Decommissioning. Imbuing the DGR with a moral responsibility for South Bruce's economic future is predicated on the belief that technology's benefits are "unbounded," while any risks are viewed as minimal (Jasanoff & Kim, 2013, p.190). This belief does not emerge in isolation, but draws on a broader social and cultural belief to technological progress as inherently beneficial. Techno-optimism is often a core feature of STI, and reflects an ideology that technology can be the sole deliverer of a near perfect society (Segal, 1986, p.149).

The case studies on techno-optimism as a STI often reflect economic motivations and rationalizations. In his study of silicon valley's utopian visions of outer space, Tutton (2021) observes that STIs are framed in terms of personal desire, a capitalist logic that drives these often abstract visions of progress. Techno-optimistic STIs often operate in terms of affect, as Hughes (2024) analyzes their utopian, productive and collectivizing affective nature. In terms of utopianism, STIs conceive of how life ought to be, productive refers to how projects are realized,

and collectivizing connects the individual to a shared social and moral order (p.909). These different approaches all work towards a collective temporal goal of orienting technological visions of the future. Mayor Mark Goetz is not invested in the DGR as a present project offering economic benefits; the timeline is such that upon approval, the NWMO wouldn't even begin construction until 2036 (Hosting Agreement, n.d.). Mark is buying into the STI of the project that upon realization of the project, South Bruce will be a cultural and economic hub. The affective work here is being done by the productive capacity of STIs (McNeil et al., 2017). Simply put, by framing the DGR in techno-optimist accounts, the NWMO is invested in future visions of progress, rather than present negotiations of risk.

This is not to say Mayor Mark is wrong to lean into STIs which project a future vision of his community which aligns with his own nostalgic memories of a once strong and successful South Bruce. Nostalgia is a powerful tool in the relationship between community and infrastructure. Nostalgic discourses within energy and infrastructure are often studied through the struggles of individuals accepting the death of a community industry, and the connection between emotional bonds and socio-economics (Ampadu, 2026; Bell & York, 2010). The reverse of this is when nostalgia is embedded in the psychology of a campaign, where energy or environmental infrastructure is presented as an opportunity for community participation (Pappa, 2025). In this vein, Mark doesn't see a productive future for dairy farming, and driven by an aging population and lack of skilled labour, he can project a nostalgic return to the community of his childhood on to the nascent nuclear waste industry. In this way, the DGR is discursively transformed from a technical solution to nuclear waste into a vessel for nostalgic hope, where economic precarity and demographic decline are reconciled through the promise of technological

progress. Maartje and Cathy see the DGR in a different light, through an effort to reorient their community from an agrarian to technological.

Maartje, Cathy, and Community

The fissure between Maartje and Cathy and the NWMO is described by Bell (2023) as “epistemic tensions,” in their assessment of the South Bruce DGR. While Bell explores the ways in which the NWMO dismisses lay knowledge in the broader context of Bruce County and the history of nuclearism, the silencing that both Maartje and Cathy experience is less about discrediting lay knowledge and more about subduing legitimate opposition to the project. Wynne’s (1989) well known study of the chasm between sheep farmers and nuclear experts post Chernobyl, and the discreditation of farmer’s lay knowledge is perhaps the typical route to base the tension Maartje and Cathy express. While there are epistemological divides with respect to potential issues such as water contamination and radiation leakage, the real divide is on a STI plane. Maartje and Cathy are primarily concerned with South Bruce as their home where intergenerational farms can thrive, rather than a hub for future energy infrastructure. Their concern illuminates a historically significant trend where there is an assumption that rural and indigenous land can always be subjugated in the name of green energy development (Chen, 2019). The reality that many rural communities exist within a modality where economic survival often hinges on extrativist/energy infrastructure often feeds into the belief that they are always in a state to be “refigured” (Malin et al., 2019; Chen, 2019).

On a communications front, the NWMO engaged in a campaign based on acceptance, underpinned by economic promises. In their research on energy transitions, Conde &

Takano-Rojas (2025) claim that often policymakers assume that the best communication strategy for infrastructure development revolves around mitigating resistance, when in reality this does nothing to interrogate the socio-economic order than drives communities (p.9). While it sounds trivial, the NWMOs failure to have the Gay Lea or Chapmans Ice Cream as supporters of the project is a failure to recognize the socio-economic culture which drives Teeswater. Gay Lea never officially came out for or against the DGR, but Chapmans Ice Cream vice-president Ashley Chapman did, and said, "Having a nuclear waste dump smack dab right where I get all my dairy for my product doesn't fill me with joy"... "To think that we could have a nuclear waste dump in such a strategically important processing area for dairy is just silly" (Butler, 2020). The Gay Lea creamery in Teeswater supplies much of the dairy for the Chapmans Ice Cream, a proudly Canadian company and a beacon of Bruce County. This is not to discount the legitimate science based opposition to the project, nor the knowledge gained by community members through their own research on nuclear waste and disposal. This failure represents the chasm between the competing visions for South Bruce, and the current economic and cultural reality for the community.

There are still epistemic divisions on the safety of the DGR. The groups which protested the development of a DGR in South Bruce still exist currently, with renewed focus on Ignace. When the project began site testing and land purchases, several groups arose in resistance to the NWMO, including *Protect our Waterways*, *We the Nuclear Free North*, and *Protect South Bruce*. Each organization engages in their own science based risk communication to combat the eventual construction of the DGR. On the *Protect South Bruce* website, they press that people should know the risks, and reference several waste related accidents, including the

aforementioned Waste Isolation Pilot Project (WIPP) in New Mexico, U.S.A., a Swedish study which flags corrosion in copper nuclear waste receptacles, and a dubious article on a German nuclear waste leak. On *We the Nuclear Free North*, there are explanations as to why ground water will be impacted by the DGR, claims of greenwashing nuclear energy production, and concerns about transportation. In all these cases, the NWMO has hoards of engineers and scientists working on the efficacy of transportation, the design of the casks being buried, and endless environmental assessments and testing of the proposed DGR location. There are still legitimate concerns raised by these organizations, such as gaining consent from indigenous communities along the waste trucking route, and the dangers of ionizing radiation, should there ever be a leak. Along with dueling epistemic tensions, the communities at hand are also expressing temporal concerns with the future, and in turn attempting to protect their ontological reality.

The risk that the project doesn't reach fruition also needs to be taken into consideration from a community point of view. There is a growing body of literature which analyses how "ghost projects," that is large scale infrastructure which is never completed, can impact a community. The DGRs scale, cost, and consent model all lend to a consideration that the techno-optimistic visions for South Bruce may not come to fruition. Ghost projects, as defined by Muller-Mahn et al. (2026) are, (projects which) exist in the twilight zone between imagination and the shabby reality of incomplete or abandoned development activities. They are transient phenomena, positioned somewhere between the past and the future, strangely uncertain and disquieting, as if history had lost its way. Ghost projects are related to the promises of infrastructure development and the messy or messed-up prospects of ruined futures" (p.2). Large scale infrastructure is perhaps a concerning phenomena to place STIs upon, as Larsen et al.

(2024) show that transnational energy megaprojects exert real political and social effects even when unbuilt, as their promises and financing unfold across dispersed “elsewheres” that shape publics, expectations, and communities beyond the site of construction. Furthermore, even with a consent model, the power imbalances in these infrastructure projects are still stark. As Flensburg & Lai (2025) write, when a project isn’t completed, the developers and institutions in charge are still paid for the work they put in, but there is little insurance for a community who was banking on economic opportunities should the infrastructure be completed. I bring in the example of ghost projects to argue that beyond community based concerns, there are consequences to the material reality of being promised large scale infrastructure, such as prolonged states of uncertainty and the local absorption of risk.

Conclusion

This chapter examines the proposed Deep Geological Repository in South Bruce as more than a technical solution to nuclear waste management, arguing instead that it functions as a contested socio-technical imaginary through which competing visions of community, economy, and temporality are articulated. While the NWMO presents the DGR as a pragmatic, safe, and economically transformative infrastructure project, local resistance reveals that alongside epistemic gap between experts and lay publics, this conflict unfolds at an ontological level, where the community is hesitant to move from an agrarian society to one qualified by long-term nuclear waste risk. By situating nuclear waste within theories of risk, waste, and socio-technical imaginaries, this chapter shows how the DGR is discursively mobilized as a stabilizing force against temporal uncertainty. The NWMO’s emphasis on passive safety and geological permanence aims to neutralize the perceived dangers of nuclear waste by rendering it as a

non-concern. Yet for residents such as Maartje and Cathy, this promise of permanence collides with lived experiences of farming and intergenerational planning. Their concerns are not simply about radiation exposure or engineering failure, but about the reordering of local life around a project that threatens to displace their socio-economic identity.

While community-based siting represents a rhetorical departure from earlier extractivist and imposed infrastructure projects, it does not eliminate the power imbalances. Instead, it relocates responsibility onto communities that must weigh long-term, uncertain risks against short-term economic incentives, often under complicated conditions of economic precarity. In this sense, consent becomes a negotiation under constraint. Importantly, this chapter also highlights the affective and temporal dimensions of techno-optimism. For Mayor Mark Goetz, the DGR is imbued with nostalgic hope, a conduit through which South Bruce might recover a sense of security. Yet such imaginaries risk exposing communities to the possibility of “ghost projects,” where promised benefits of large scale infrastructure projects fail to materialize. The South Bruce case demonstrates that nuclear waste governance is not merely a matter of engineering adequacy or risk calculation, but a profoundly social and cultural process. As Canada moves forward with its nuclear energy ambitions and long-term waste strategy, the tensions documented here underscore the need to interrogate how socio-technical imaginaries distribute risk, reward, and agency across communities.

Conclusion

In the introduction to this project, I outlined Germany's reaction to Fukushima and its subsequent reversal. The starkest example of the shift from risk to reward, however, is in Japan where the Fukushima meltdown left a legacy of health, environmental, economic, and political fallout. Yet even there, public and political attitudes have begun to change. In February of this year, TEPCO, the company responsible for operating Fukushima at the time of the disaster, restarted Japan's first nuclear reactor under its management in fifteen years, signalling a break from the post-Fukushima shutdown era. The contemporary nuclear moment is therefore defined not by the disappearance of peril, but by a more nuanced appreciation of nuclear energy as a potential safeguard against climate change and energy security. While one could argue that this is merely a continuation of the longstanding promise-peril binary, contemporary nuclear discourse is more complex. Nuclear energy no longer has to carry a utopian load; renewable energy technologies are now cheap, clean, and being deployed rapidly. Within this context, nuclear energy is being repositioned less as a futuristic utopian technology than as a dependable source of carbon-free baseload power in an energy landscape defined by instability (see the Iran war oil crisis) and transition.

One of the central conclusions of this dissertation is that nuclear energy risk discourses have both changed and endured across time. Many of the core tropes and discursive formations that emerged in the early atomic period continue to shape how nuclear energy is understood today. At the same time, new discursive formations have emerged within a transformed energy landscape, particularly those tied to decarbonization. Risk, then, is not static, nor is it universally perceived in the same way across time and space. Rather, it is continually reconfigured within

specific political, cultural, national, and environmental contexts, taking on different meanings depending on the material conditions of a given moment. Attending to discourse is therefore especially valuable when analyzing a highly contested technology such as nuclear energy, because it allows us to move beyond rigid ideological positions and instead examine how meaning is constructed. In doing so, discourses of risk reveal not only what people think about nuclear energy, but the contexts in which people fear or rally around a nuclear future. Another key takeaway is that policy motivations are often central to shifts in nuclear risk discourse. Discursive change does not occur in isolation; they are frequently bound up with specific political moments that make certain representations of nuclear energy more desirable or pragmatic. In the Canadian context, renewed policy support for nuclear expansion has coincided with new forms of industry communication that emphasize nuclear energy as green and efficient. This suggests that changing discourses of risk are often cultivated alongside broader institutional efforts to legitimize certain energy futures.

Other takeaways were less intellectual and more practical. This dissertation was also shaped by a motivation beyond academia: it became, in part, a way of developing the skills needed to understand how the nuclear energy industry communicates risk, and how those communications attempt to reposition nuclear energy within changing political and cultural conditions. Finally, writing this project was valuable not only for the conclusions it reaches, but for the process it required. Working through the literature, histories, and case studies became a way of understanding more clearly how nuclear risk is constructed not only culturally, but also intellectually across different scholarly fields. In that sense, this project has been as much an

exercise in learning how risk discourse is constructed and mediated as it has been an effort to produce a critical judgement about nuclear energy and risk.

Further Research

A further area for research lies in more analyses of community resistance and consent processes, particularly as nuclear siting increasingly relies on community acceptance structured through economic incentives. More work in this area could help uncover industry blind spots by showing how host communities understand these projects in ways that exceed simplified assumptions about the need for labour or compensation. Relatedly, the nascent field of nuclear advertising deserves scholarly attention. As nuclear industries and utilities increasingly invest in branding, public communications, and image rehabilitation (recasting rather), there is a growing need to study how these campaigns construct nuclear energy legitimacy and risk. Another area for research is the relationship between energy policy language and broader public discourse. Policy does not simply describe energy futures in neutral terms; they help produce the syntax and nomenclature through which those futures become understood. Studying how terms travel between policy, industry communications, and media could reveal how particular energy sources are constructed.

Further research is also needed on Indigenous resistance and acceptance of nuclear projects, particularly given the longer histories that shape these responses. Cases such as the Western Shoshone opposition to Yucca Mountain in Nevada, and the enduring environmental and health legacy of uranium extraction around Elliot Lake and Serpent River First Nation, suggest that Indigenous perspectives are essential to any fuller account of nuclear energy politics, contemporary nuclear waste siting, and consent. Finally, more attention should be paid to the

gendered dimensions of nuclear risk discourse. Across civil defense culture, the domestication of the bomb, and environmental and health-based anti-nuclear activism, women have often been positioned as guardians of domestic safety and children's vulnerability. For example, throughout the civil defense era, women were specifically targeted in public education campaigns. This included films like *The House in the Middle* (1954), which claimed that if housewives kept a tidy home and yard, they could help prevent fires after a nuclear explosion. Home economics curriculum in the 1950s even taught high school aged girls how to properly furnish and provision basement shelters, folding Cold War anxieties into the routines of domestic life. This is one example of how nuclear risk can be rhetorically mediated through feminized care and protection, and further research could deepen the understanding of how radiological danger becomes personalized and gendered.

Final Reflections

Nuclear energy production is not without risk, however, a present overstatement on the historical risks nuclear energy presents is a risk in and of itself. It is therefore key to strike a balance, both attending to the real risks that nuclear energy presents, while also appreciating that discourses of risk carry too much contemporary weight. The way in which technologies are rendered intelligible, interpreted, legitimized, and deployed hinges largely on the discourses which frame them. Ongoing energy negotiations therefore require scholarly intervention not only to evaluate technological systems on material grounds, but to interrogate the communicative conditions through which those systems are made meaningful. If nuclear energy is to be understood clearly in the present, it must be approached not as a technology fixed by the

catastrophes of its past nor redeemed uncritically by the promises of its future, but as a contested object whose risks and rewards are continuously produced through discourse.

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