THE PROCESS MODEL OF DISPLACEMENT:

A CASE STUDY ANALYSIS OF

THREE NUCLEAR TECHNOLOGY PROJECTS

by

Kathleen M. Saul

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Energy and Environmental Policy

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“Alone we can do so little; together we can do so much.”

Helen Keller

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LIST of ACRONYMS and ABBREVIATIONS

U.S. AEC	U.S. Atomic Energy Commission
AERB	Indian Atomic Energy Regulatory Board
BARC	Bhabha Atomic Research Centre (India)
BRNS	Board for Research in Nuclear Sciences (India)
BWR	Boiling Water Reactor
CEA	French Commissartiat a L'Energie Atomique
CEZ	Chernobyl Exclusion Zone
CWPRS	Central Water and Power Research Station, Pune
DAE	Indian Department of Atomic Energy
DOE	U.S. Department of Energy
EA	Environmental Assessment
EAC	Indian Expert Appraisal Committee
EDF	Electricite de France
EIA	Environmental Impact Assessment (India)
EPA	U.S. Environmental Protection Agency
EPR	European Pressurized Water Reactor
Euratom	European Atomic Energy Community
GE	General Electric
IAEA	International Atomic Energy Agency
MoU	Memorandum of Understanding
NEA	European Nuclear Energy Agency

NEPA	U.S. National Environmental Policy Act
NEERI	National Environmental Engineering Research Institute (India)
NIOSH	National Institute for Occupational Safety and Health
NKVD	Soviet People's Commissariat for Internal Affairs
NOAA	U.S. Department of Commerce National Oceanic and Atmospheric Administration
NPCIL	Nuclear Power Corporation of India Limited
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
NWPA	U.S. Nuclear Waste Policy Act of 1982
OA	U.S. Office of Independent Oversight and Performance Assurance
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor
RBMK	Soviet-style Reaktor Bolshoy Moshchnosty Kanalny
ROI	Return on Investment
RPS	Renewable Portfolio Standard
SIA	Social Impact Assessment
TEPCO	Tokyo Electric Power Company
TISS	Tata Institute of Social Sciences
UKAEA	British Atomic Energy Authority

UN	United Nations
UNAEC	United Nations Atomic Energy Commission
VEGP	Vogtle Electric Generating Plant
VVER	Soviet-style pressurized water Vodo-Vodyanoi Energetichesky Reaktor
WPPSS	Washington Public Power Supply System

ABSTRACT

The analysis of displacement associated with mega projects, like the construction and operation of nuclear facilities, has largely been event-based. Examination of nuclear technologies has usually focused on technical, economic, political, and, in some cases, environmental factors. In this dissertation, I maintain that social dimensions need to be added to those examinations. Social dimensions appear in the form of physical, emotional, social, and psychological displacement of people throughout the life cycle of nuclear projects, from planning through waste disposal. Understanding displacement in this context requires a framework and methodology that conceives of displacement as an enduring, evolving, open-ended process. A Socio-Political Ecology framework helps us understand how nuclear projects influence, and are influenced by, human wants and needs, environmental conditions and resources, attitudes towards risk, and the existing political climate. The framework also draws attention to the impact of those factors on the social environment in general, and on the displacement of people in particular. Using a Process Model of Displacement we can examine displacement not as a one-time event but rather as a multi-faceted, on-going process that begins when the planning begins and does not stop even when the doors of the facility have been closed. The framework and Process Model of Displacement are validated in this dissertation using

data gathered from the three case studies: The Hanford Nuclear Reservation, Washington; the Chernobyl Nuclear Power Plant, Ukraine; and the proposed Jaitapur Nuclear Power Plant, Maharashtra, India. The Process Model of Displacement reveals negative social consequences of nuclear technology that have occurred throughout its history, continue to occur in the present, and will need to be planned for in the future. Those negative consequences and the impacts on society need to be at the forefront of policy-making and decision-making about nuclear technology and other mega projects.

Chapter 1

NUCLEAR TECHNOLOGY AND DISPLACEMENT

> Recall the face of the poorest and most helpless person . . . and ask yourself if the step you contemplate is going to be of any use to him. Will he be able to gain anything from it? Will it restore him control over his life and destiny?
>
> Mahatma Gandhi

Scholars of the history of technology provide a myriad of examples of the ingenuity, skill, determination, and luck through the ages that have led to the development of devices like the electric battery, pumps that lifted the water out of increasingly deep British coal mines, and the network of interconnected distribution wires that transfer electricity from electric generating plants to the masses. Each technology evolved from a particular set of circumstances, a time and a place, and decisions made by the individuals and institutions involved. This dissertation focuses on one type of technology, nuclear reactor technology, the conditions that led to its emergence and continued presence around the world, and, most importantly, the social, psychological, cultural, and physical displacement that resulted from the planning, construction, operation, and ongoing clean-up and protection of reactor sites. Throughout this dissertation the phrase "nuclear technology" refers to land-based nuclear reactors developed to harness the power of the atom. It encompasses the variety of designs employed, as well as the complex processes and skill sets that evolved to bring them to fruition. During World War II reactors generated the raw materials for atomic bombs; since that time the focus has been on maintaining stockpile of weapons and developing the technology for electricity generation. This dissertation does not deal with nuclear-powered submarines, nuclear medicine, or other such applications.

It is argued that:

1. While decisions about the use of nuclear technology usually focus on technical, economic, political, and perhaps environmental factors, those decisions also have a social dimension (one that goes beyond the delivery of electricity): they affect people, their livelihoods, where and how they live.

2. Social dimensions manifest themselves in the physical and psychological displacement of people throughout the life cycle of nuclear projects. Displacement does not occur only when shovels move earth to construct a facility and families are forced to leave their homes. It starts during the planning stages and continues long after the lights have been turned off at that facility.

3. Current analyses of nuclear technology either ignore displacement or treat it as a one-time event, usually associated with the construction at the site or a catastrophic accident.

4. Understanding the social dimensions and displacement associated with nuclear technology thus requires an analytical framework and methodology that conceives of displacement as a process, an often open-ended process. That framework and methodology are presented in this dissertation.

5. The process approach to displacement helps us better understand some of the negative consequences of nuclear technology that have occurred throughout its history and continue to occur in the present. Recognizing that displacement does not just occur at one point in time highlights one key reason governments, nuclear power companies, and local people have had differing views about the social impacts of nuclear technologies. And, as a result, understanding the social dimensions and displacement provides a more complete picture of the consequences of a nuclear technology project.

The value of the approach can be appreciated by examining three cases studies: The Hanford Nuclear Reservation, Washington; the Chernobyl Nuclear Power Plant[1], Ukraine; and the proposed Jaitapur Nuclear Power Plant, Maharashtra, India.

Before exploring the theories proposed as foundational to this research in the chapters that follow, this dissertation begins with a brief review of the history of nuclear reactor technology. It starts by looking at the coming together of great minds of the world to unlock the mysteries of atomic energy. It moves on to discussion of the formation of national and international institutions to oversee civilian and military uses of that energy. It explains the cloak of secrecy that has enveloped the nuclear industry, prevented the public from understanding the real issues facing it and from being able to get answers to their questions. It concludes by examining an industry which in modern times touts its small carbon footprint and ability to provide large quantities of baseload electricity, but has not yet found a solution to the problem of long-term waste storage. It is against this global historical backdrop that the theoretical frameworks discussed in Chapters 2 and 3 can be understood.

1.1 A Brief Review of Nuclear Technology Development

1.1.1 The Early Years—through the 1950s

As early as 1938, the idea of harnessing the power of the atom for the benefit of mankind had moved from the pages of science fiction novels to those of scientific journals. In his acceptance speech for the 1938 Nobel Prize in Chemistry for the discovery of artificial radioactivity, shared with his wife Irene, Frederic Joliot-Curie explained:

> If we look past scientific progress, pursued with ever increasing speed, we may reasonably expect future research workers, breaking down or

> building up atoms at will, to be able to achieve explosive nuclear chain reactions. If such transmutations can be propagated in matter, we can envisage the liberation of enormous quantities of usable energy.[2]

That usable energy would far eclipse that of coal or biofuels, the main sources of energy at the time.

By the outbreak of the Second World War, scientists in Germany, France, Great Britain, and other Western European countries had been hard at work on understanding the nuclear fission process and unlocking its power. As Hitler's armies marched across the European countryside, and German scientists explored the uses of heavy water reactors[3], many of the great minds of other countries escaped to the United States to work on the ultimate deterrent: the atomic bomb. Albert Einstein had renounced his German citizenship to escape the Holocaust and settled in New Jersey; Enrico Fermi boarded a train in Italy to accept the Nobel Prize but continued to the United States instead of returning home; Niels Bohr came to the United States from Denmark via Sweden and England; and Bertrand Goldschmidt left a divided France and became the only French scientist to work on the Manhattan Project. They joined scores of other brilliant researchers who worked tirelessly and under a cloak of secrecy to move the atomic bomb from the drawing board to the demonstration scale to full scale production of plutonium at the Hanford Engineer Works in Washington State and uranium production at Oak Ridge, Tennessee, to final assembly and testing at Los Alamos, New Mexico. Only three years elapsed between Fermi's groundbreaking controlled fission reaction at the University of Chicago until the atomic bombs dropped on Japan.

Unlike the great steam engines that powered locomotives or the enormous turbines being built to generate electricity at dams like Grand Coulee in Washington

State that relied on gears, shafts, pumps, and other mechanical devices, the nascent nuclear technology was, at its core, extremely scientific. The average person could not understand its complexities. Discussions of nuclear power involved supercritical masses, radioactive decay and half-lives, moderators, and cooling water. Construction of nuclear facilities involved familiar elements: concrete, electrical wiring, air and water handling systems, ducting, and the like. However, these elements were combined and layered in ways no one had ever seen before. Consider the core of the Hanford (Washington) B reactor, the world's first full-scale nuclear reactor, for example. To produce plutonium needed for atomic weapons, 100,000 specially milled graphite bars (about 2,000 tons of graphite) surrounded the tubes containing uranium slugs.[4] That structure was enclosed in 10 inches of cast iron blocks and a four-foot "biological shield" of masonry and steel. Another three to five feet of concrete surrounded that. About 30,000 gallons of water per minute flowed through the graphite bars to remove the heat generated by the nuclear reactions.[5] These multiple, physical layers of protection and separation from radiative materials later became known by industry insiders as "defense in depth."

The war effort had favored military applications of the atom. After seeing the devastation and impact on human lives after atomic bombs obliterated Hiroshima and Nagasaki, Japan, many pushed for peaceful, civilian applications of this awesome new technology. Addressing listeners in the United States by radio after the Potsdam Conference in Berlin, President Harry S Truman urged:

> We must constitute ourselves trustees of this new force, to prevent its misuse and to turn it into channels of service to mankind. It is an awful responsibility which has come to us.
>
> Harry S Truman, August 9, 1945[6]

The question then became how to prevent the misuse of nuclear power and the spread of nuclear weapons. Many scientists and engineers with knowledge about nuclear technology had returned to their native countries. The Prime Ministers of Great Britain and Canada and U.S. President Truman argued to the newly formed United Nations (UN) that maintaining secrecy and a monopoly on uranium would provide the surest guarantee of preventing other nations from acquiring the weapons.[7] The UN Security Council worked for years to hammer out the details of an agreement that would address concerns of all parties; the first Treaty on the Non-Proliferation of Nuclear Weapons was signed in July of 1968 and entered into force two years later.[8] During the interim years, the British exhibited their nuclear weapons capability with tests over the Montebello Islands of Australia,[9] the French carried out tests in the Saharan desert,[10] and the Soviets detonated several plutonium and uranium bombs over rural areas of their country.[11] Other nations, including Austria, Finland, and Italy, agreed to forego weapons development entirely.

That the Soviets had a fully developed nuclear program surprised some until the exposure of spies working within the Manhattan project: Theodore Hall, Klaus Fuchs, David Greenglass, and others. They had revealed many of its secrets to the Soviets during the 1940s.[12] Interestingly, plans for the Hanford Works in Washington helped form the foundation of some of the structures at the Mayak Nuclear Complex in the Urals.[13] Soviet leaders then chose the experienced and knowledgeable engineers from the Mayak project to design new, six-reactor complex for Ukraine.

Experts from the Mayak Nuclear Complex also joined the teams of liquidators decades later in April 1986, assessing the extent of radioactive contamination in the evacuated zone around the Chernobyl Nuclear Power Plant.[14]

As research into the uses of power of the atom shifted from weapons to civilian applications, countries that had weapons technology gained a foothold in the creation of nuclear reactors that would generate electricity. Institutions in the United States, the Soviet Union, France, Great Britain and Canada already possessed the expertise, capability, and capacity to explore electricity production. This led to a situation in which a few countries retained control over the technology and others that wanted access had to make special arrangements to gain it.

1.1.2 Institutional Oversight

To help oversee their expanding applications of nuclear technology, the Soviets created a Special Committee, and under that a new First Main Committee (to develop uranium mines, nuclear plants, and research institutions) and a Scientific Technical Council (focused on research that would lead to an atomic bomb). The construction arm of the People's Commissariat for Internal Affairs (NKVD) supported the endeavors, as did Minergo (the Ministry of Energy), responsible for policy and legal regulation of electricity production, and Glavatomenergo (Administration of Construction of Atomic Power Plants). In essence, the Communist Party elite directed the expanding Soviet nuclear enterprise from their offices in Moscow.

The U.S. Army and the U.S. government had controlled the use of nuclear technology, the production of nuclear fuels, and all information about the related sciences in the United States during World War II. In Great Britain, the Department of Scientific and Industrial Research, Directorate of Tube Alloys, had taken on the task of developing a uranium bomb at the behest of Sir Winston Churchill.[15] The agreement "Governing Collaboration between the Authorities of the U.S.A. and the U.K. in the Matter of Tube Alloys" set forth the strict terms of information sharing between the different groups and any outsiders. The agreement also gave the United States and Great Britain a virtual monopoly over uranium supplies in the Western Hemisphere.[16] After the war, some of that control remained with the respective governmental bodies but some devolved to various agencies and commissions. In the United States, the commercialization of electricity production from nuclear power required a champion, a backer. That became one of the roles of the U.S. Atomic Energy Commission (U.S. AEC), formed in 1947 to oversee the plants, laboratories, equipment, and personnel that had been assembled under the Manhattan Project. The U.S. AEC promoted the use of nuclear power, supported research into nuclear technologies, developing standards governing radiation and nuclear reactors, and ensuring the safety of the American public.[17] The French had established the Commissartiat a L'Energie Atomique (CEA) in 1945 to develop all applications of the science of the atom, with a focus on its use for electricity production and propulsion.[18] That same year saw the formation of the British Atomic Energy Authority (UKAEA) to oversee research and development of nuclear power for both civilian and military purposes, with a focus on the production of weapons grade fuel and the creation of prototype reactors.[19]

Two different multinational organizations originated in Europe as well. Euratom (the European Atomic Energy Community) emerged out of a desire to pool scientific and technical knowledge of participating countries and to ensure their access to fissile materials. The treaty for Euratom was signed in 1957. The European Nuclear Energy Agency (NEA) was originally formed by 17 European nations and the territory of Trieste in 1958, but has since welcomed participation from Japan, Australia, Canada, and the United States. As part of the Organization for Economic Co-operation and Development, it aims to provide the "scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes."[20]

At the international level, the UN created its own Atomic Energy Commission (UNAEC), which in turn proposed the formation of the International Atomic Development Authority to manage and control all nuclear activities "potentially dangerous to world security."[21] Objections to the complete surrender of power to an international body ultimately sank the proposal and the UNAEC disbanded at the end of 1949.[22] However, in his 1953 "Atoms for Peace" speech to the General Assembly of the United Nations, U.S. President Eisenhower again proposed the formation of a central international agency to take charge of stockpiles of fissionable materials, to allocate those materials to serve the peaceful pursuits, including providing electrical energy to the power-starved areas of the world.

> [T]he United States pledges before you – and therefore before the world – its determination to help solve the fearful atomic dilemma – to devote its heart and mind to find the way by which the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life.
>
> Pres. Dwight D. Eisenhower, Dec. 8, 1953[23]

The UN agreed to convene the first “Geneva Conference” of 1,500 delegates and countless scientists. The conference affirmed the possibilities of nuclear technology and set in motion the processes that resulted in the formation of the International Atomic Energy Agency (IAEA) in 1957. The UN charged the agency with promoting research and development of the practical peaceful applications of nuclear energy; providing the materials, facilities, services, and support for that research and development; fostering the exchange of scientific and technical information; ensuring the assistance and supplies provided by the IAEA would not be used for military purposes; and establishing standards for nuclear safety.[24] The IAEA would report directly to the UN General Assembly and the Security Council. Like the physical defense in depth, the nuclear industry created layers of agencies and organizations that also would strive to protect the workers and public from the dangers associated with nuclear power.

Still, individual government participation in the fledgling civilian nuclear industry was critical. In the United States, for example, although the government encouraged private ownership of nuclear power plants, few insurers were willing to underwrite the construction and operation of this very risky new technology. Without that, utilities would not invest. Congress stepped in, passing the Price Anderson Nuclear Indemnity Act of 1957. The Act required nuclear licensees to purchase the maximum amount of insurance available to them from the insurance market (about $60 million at the time). The U.S. government would then contribute $500 million to cover claims exceeding that amount.[25] This Act, in essence, capped the liability of the reactor licensees for any accidents resulting from the operation of nuclear power plants. In France, the state-owned Electricite de France (EDF) partnered with CEA to design and construct a natural uranium/graphite reactor.[26] The first commercial scale reactor went on line in 1964 in Chinon, on the Loire River. In Great Britain, the civilian reactors also belonged to the national utility, the Central Electricity Authority/Generating Board, whereas those with military purposes remained under the close control of the UKAEA.[27] Without those partnerships, civilian reactor programs may never have gotten off the ground.

1.1.3 Secrecy--Another Layer of Defense in Depth

Another layer protecting the public, nuclear workers, and the nuclear industry was secrecy. The urgency of the war and the need to prevent the Germans from learning the secrets of atomic bomb construction had mandated strict secrecy for everyone working on the Manhattan Project. General Leslie Groves and Colonel Frank Matthias chose the Hanford site because of its remote location (for both safety and security reasons). People working on various phases of construction of the facilities there had no idea what they were building, nor did the DuPont engineers working there a year later. General Groves, Director of the Manhattan Project, stressed that compartmentalization of knowledge “was the very heart of secrecy . . . each man should know everything he needed to know to do his job and nothing else.”[28]

Under the Soviet system, secrecy allowed for the construction of special cities that would house the scientists, engineers, and specially trained operators of their nuclear power facilities. Those living within the cities had access to better housing, food, medical care, education, and recreational activities than did the average Soviet citizen.[29] In the United States, secrecy allowed companies to dabble in reactor design without losing competitive advantage. But secrecy also had a downside. A fire ravaged the core of the air cooled uranium reactor at the Windscale works in Sellafield, England in October of 1957. About 10 tons of fuel melted[30]. Radioactive iodine-131, caesium-137 and xenon-133 escaped into the atmosphere. The government made no effort to evacuate the people from the surrounding area; however, due to fear of contamination with radioactive iodine, milk from farms within 500 km^2 (about 194 square miles) of the site was destroyed the next month.[31] The Penney Report, issued at the end of that month, indicated there was no immediate concern for the health of the public or workers at the facility. Transcripts of the proceedings of the enquiry into the aftermath of the fire--submitted to Parliament in November 1957 but not released to the public until 1988--indicated concern over elevated radioactivity in thyroid glands and yet the medical expert giving testimony felt that giving iodine pills to the local population would be a bad idea, psychologically, and probably would not be of much value.[32] Studies have not been able to link exposure to radioactive gases from Windscale and subsequent appearance of cancers. However, discovery of the lack of disclosure of information about the potential issues related to the fire resulted in distrust of the nuclear establishment by members of the public. That distrust was hard to shake. That legacy of secrecy continued through the decades as the nuclear industry sought to hide the potential impacts of radiation exposure on human health and the environment, and the true economic costs of nuclear power plants from the public.

By the end of the 1950s, nuclear technology had established itself in both the military and civilian arenas. Although governments did relinquish some control, government support remained critical for supporting the commercial applications of nuclear power. It was during this period that public-private partnerships emerged in support of nuclear power.[33] Also important were national and international agencies and organizations that provided forums for sharing information and data, safeguarding stockpiles of fissile materials (uranium and plutonium), and establishing standards for equipment design and safety that could be relied upon the world over. Keeping secrets from or withholding information from the general public also became increasingly common.

1.1.4 The 1960s through Chernobyl—Development of Commercial Nuclear Power

As shown in Figure 1.1 below for the United States, both the number of nuclear power reactors and their size increased dramatically during the 1960s and 1970s.[34] As the size of the reactors increased in response to expected electrical demand growth, so did the complexity of the designs. Utilities and power companies selected a pressurized water reactor (PWR) or a boiling water reactor (BWR), but then customized the basic plan to meet the needs and specifications of the specific site and customer. That called for an ever evolving set of safety standards and regulations, and often led to changes in the design and costly rework after construction had already begun.

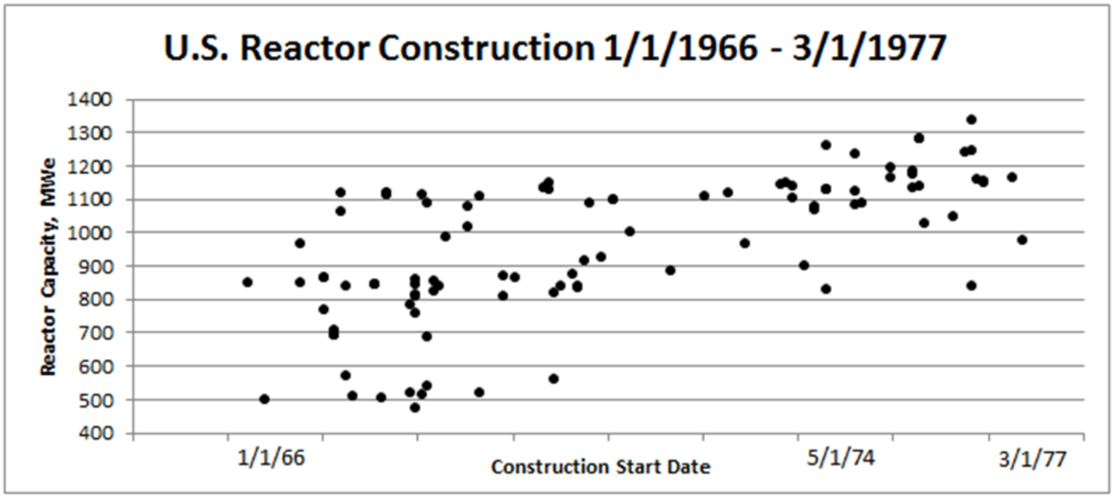

Figure 1.1 U.S. Reactor Capacity 1966 - 1977

The PWR and BWR differ primarily in the manner in which they create the steam that feeds the turbine, eventually generating electricity. Two separate loops circulate the water coolant through PWRs.[35] The primary loop contains high pressure water (about 150 times atmospheric pressure, or 150 atm) that carries heat from the reactor core to a steam generator.[36] That heat converts the lower pressure water in the secondary loop to steam, steam that drives the turbine. In the BWR, water travels through the core of the reactor, absorbing heat until it reaches the boiling point (about 285 ^{o}C), generating a steam/water mixture.[37] After separating the water from the steam, the heated steam travels through pipes to the turbine/generator. Both the PWR and BWR use water as the coolant, both house the reactor cores in steel and concrete containment structures and both are equipped with emergency core cooling systems that can be powered by the electrical grid or backup generators. A PWR typically contains 150 – 200 fuel assemblies (bundles of fuel rods containing a form of enriched uranium) whereas a BWR houses between 350 and 800 fuel assemblies.[38] About twothirds of the reactors constructed in the United States between 1966 and 1977 (Figure 1.1) were pressurized water reactors.[39]

After an initial set of fixed cost, "turnkey" contracts, which proved beneficial to the electric utilities but not the contractors, the costs of constructing and licensing commercial nuclear power reactors in the United States jumped. Factors contributing to the rising costs included inexperienced local labor pools and the inability of the U.S. AEC to cope with the sheer number of licensing requests.[40] Delays in finishing the facilities increased the cost of borrowing money and thus the total construction cost.

Following the construction of a number of small capacity reactors in the 1950s and 1960s, the Soviet nuclear establishment chose 925 to 950 MWe net (1000 MW gross) capacity for reactors built in the 1970s and 1980s. (See Figure 1.2 below.) Most of the nuclear reactors were built in clusters of two to four reactors at one site. Savings in transporting materials and equipment, in recruiting and housing construction workers at one rather than multiple sites translated into shorter times to bring the reactors on line (7.5 years for reactors in the USSR as opposed to 8.9 years on average for U.S. reactors)[41], and eventually to lower electricity generation costs.[42]

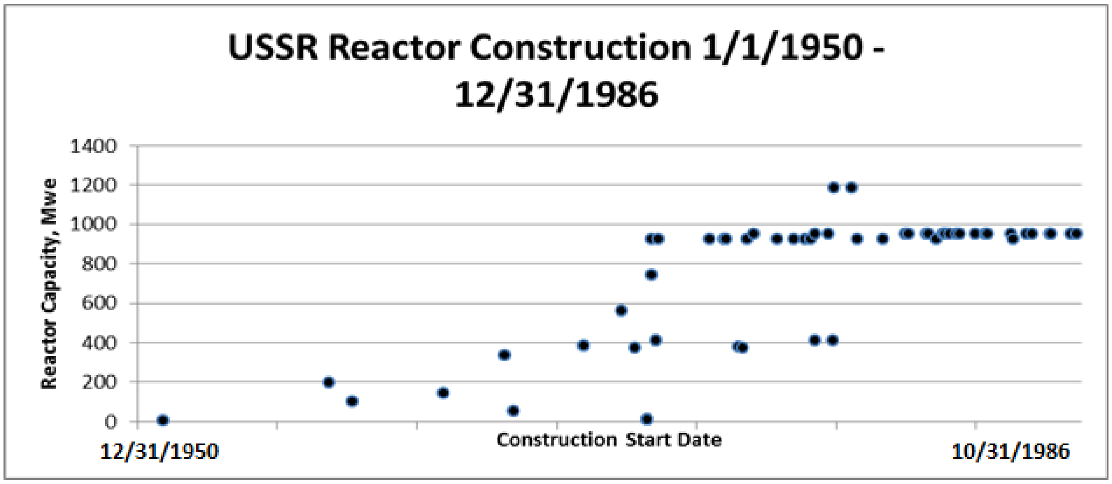

Figure 1.2 Reactor Construction in the USSR

The size of the German commercial nuclear reactors also increased from the mid-1970s through the 1980s. German boiling water reactors ranged from about 770 to 1280 MWe, whereas the pressurized water reactors spanned 1240 MW to 1400 MWe.[43] Although all had been designed and built by Siemens-KWU, the trend in costs followed those noted for nuclear power plants in the United States: costs skyrocketed as the capacity of the reactors rose.[44] Interestingly, costs for French reactors did not escalate to quite the same degree as those in the United States. Factors forcing costs up included: 1. Labor costs rising at rates greater than inflation; 2. Increasingly complex designs as components of Westinghouse reactor designs were adapted to French needs; and 3. Stiffer French regulations. The French practice of building more than one reactor of a given design at site and the standardization of reactor designs helped limit those cost increases.[45]

As the number of nuclear power reactors increased worldwide, so too did concern over reactor safety. The primary approach to safety had been “defense in depth": designing and building physical barriers between humans, the environment, and the core of the nuclear reactor. In the West, that meant redundancy in safety systems and erecting giant containment domes over the heart of the reactors. The defense in depth idea also expanded to include developing rules and procedures to prevent abnormal operations and to enable operators to detect failures should they occur.[46] At worst, defense in depth and the culture of safety it engendered would mean that plant personnel should be able to control any severe situations that did arise.

Engineers also employed Probabilistic Risk Assessment (PRA) to examine more precisely the statistical probability of a nuclear accident. PRA used event trees (models that examine and quantify the sequence of events that lead to specific outcomes) or fault trees (which work backwards from outcomes or failures to potential causes), assigning estimated frequencies to each step along the way and for each entire pathway. In this way, PRA could give the industry an idea of the relative risks associated with a variety of failures for a nuclear power plant, from something as small as a valve malfunction to something as critical as a core meltdown.[47] Although there remained some uncertainty associated with each of the calculations, PRA allowed the nuclear industry to pinpoint its vulnerabilities and remedy them, and to try to reassure the public that the risk of a core meltdown was minuscule. PRA also allowed the U.S. AEC to develop regulations for the nuclear power industry that aimed to reduce the probability of serious death or injury to a statistical person to an insignificant level.[48] Using industry assumptions and according to the multitude of probabilistic calculations, the U.S. AEC deemed nuclear power reactors "safe."

During the 1960s and 1970s, countries with nuclear technology vied to expand their reach internationally. The Soviet Union built reactors in Soviet Bloc countries --

Bulgaria, East Germany, and Slovakia--and Soviet Socialist Republics of Ukraine, Lithuania, and Russia.[49] Bechtel and General Electric constructed two enriched uranium reactors at Tarapur, Maharashtra, India under an agreement between India, the United States, and the IAEA. General Electric and Westinghouse exported reactor technology to Japan, Korea, the Philippines, Spain, and Taiwan during that period.[50]

However, accidents at Three Mile Island in Pennsylvania (March 1979) and Chernobyl, Ukraine (April 1986) did little to reassure the public's acceptance of the safety of nuclear power reactors. The release of American feature films The China Syndrome (1979) and Silkwood (1983) added to fears about nuclear reactor safety and what information the industry withheld from the public. Protesters, who had opposed bombs during the 1940s and 1950s, turned their attention to nuclear power plants in the 1970s and 1980s. In the United States, the Sierra Club, Ralph Nader, Friends of the Earth, Clamshell Alliance, the Abalone Alliance, the Conchshell Alliance, SHAD, and others used strategies of nonviolence—sit-ins, anti-nuclear music concerts, and vigils in front of the White House--to try to prevent or stop the construction of nuclear power plants in California, New York, and Oklahoma.[51] Demonstrations in Germany drew hundreds of thousands of anti-nuclear activists. The numbers were smaller in France, were police action deterred further mass gatherings.[52] Despite this public outcry, electric utilities, manufacturers, and government backers remained committed to the technology. When construction halted, it usually was for reasons such as the absence of projected electrical demand or failed finances (in the case of the Washington Public Power Supply System) rather than the pressure from the anti-nuclear movements.

Still, the catastrophe at Chernobyl in 1986 underscored the fact that nuclear accidents were not isolated incidents whose impacts stopped at the power plant property limits. Nor did it stop at the country boundary. The first indications of a problem had been detected in Sweden. The radioactive fallout blanketed most of Europe, affecting the milk and food supplies of many nations for many years. Nuclear experts from around the world gathered to assess the damage to the environment and human health but could not agree on the impact of exposure to radiation on the incidences of cancer. With the exception of thyroid cancer among children living in Ukraine, Belarus, and Russia at the time of the catastrophe, the lack of baseline data, the difficulty of reconstructing dose profiles, and confounding lifestyle factors (alcoholism, smoking, and poor nutrition, for example), made linking cancer or other diseases directly to Chernobyl radiation. However, the world became acutely aware that a nuclear accident in one nation had international ramifications.

The transition from small scale demonstration reactors of the 1950s to commercial scale nuclear power plants was characterized by delays in construction, evolving safety standards, and cost overruns. The size of the facilities under construction grew. Despite reassurances that reactors had been designed and engineered with safety in mind, and despite many years of safe operation, accidents at Three Mile Island and Chernobyl cast doubt on those claims.

1.1.5 Late 1980s to the Present

The 1982 Nuclear Waste Policy Act (NWPA) gave the U.S. Department of Energy (DOE) the responsibility for finding, building, and overseeing a geologic repository for the disposal of high-level waste and spent nuclear fuel.[53] Yucca Mountain, Nevada was the top pick for that site. The Environmental Protection

Agency (EPA) would be responsible for setting standards and policies to maintain the environmental quality at that location. The NWPA also established a fund, paid by those with spent fuel or high level nuclear wastes, to be used to offset the costs incurred by the provisions of the Act.[54] As of this writing, no geologic site has been approved in the United States; spent fuel still sits in dry casks or in spent fuel pools at each reactor site.

The French enacted a similar Waste Management Act in 1991 which requires a storage site that can hold its nuclear waste for a period of at least 100 years.[55] An underground system of tunnels constructed just over 1600 feet (500 meters) underground is planned near the city of Bure in northwestern France.[56] A long term geologic storage site is also under construction in Olkiluoto, Finland (its license was approved in November 2015.[57] The question remains: Will these sites be able to contain nuclear power plant wastes for the thousands of years necessary until they become safe to handle?

While some countries deal with issues of what to do with stockpiles of nuclear waste, others eagerly pursue nuclear power as a way to provide 1. Electricity to the growing populations in their countries (India and China), and 2. Carbon free baseload electric power in a world increasingly concerned about carbon emissions and climate change. Proponents of nuclear power cite studies that show nuclear to be comparable to wind and solar in life cycle carbon emissions.[58] The construction of the physical barriers that contribute to the safety of nuclear power contribute quite a bit to the emissions profile for a given plant, as do mining, milling, and enriching the uranium that feeds a nuclear reactor.[59] The focus on nuclear power also reflects the bias towards large scale, centralized electrical facilities—the model that drove the developed world. That model requires an integrated transmission and distribution network, utilities which are willing and able to pay the costs of constructing and maintaining that system, and customers who can afford to connect to it.

The 2011 earthquake and tsunami that crippled the Fukushima Daiichi reactors led to the meltdown of three reactor cores. Although the amount of radiation released into the environment has been estimated to be between 10% and 15% of that released at Chernobyl, the accident resulted in the creation of an exclusion zone similar to that which surrounds the Chernobyl Nuclear Power Plant.[60] Within six months, 72% of Japanese nuclear reactors had been shuttered; the rest closed in early 2012.[61] Rolling blackouts became the norm across the country. The accident also led to increased scrutiny of existing reactor designs and safety procedures, the passive safety features of new nuclear power plant designs, and to changes in policy toward nuclear power in in Japan and several countries.

In the United States, all licensed sites underwent a review, starting with those located in California and along the coasts. Inspectors looked plant emergency preparedness, and the ability to cope with extended power outages, reactor and spent fuel pool damage.[62] The 33 reactors with early containment vessel designs similar to those at Fukushima were required to install emergency venting systems able to relieve pressure in the event of serious accidents.[63] The Nuclear Regulatory Commission also issued a report recommending enhanced protection against floods and earthquakes, and provision of adequate (possibly offsite) backup power supplies, among other things.[64] The United States and Great Britain remained committed to new reactor construction programs, whereas Italy and Taiwan responded to the crisis by halting their programs.[65] In Germany, Chancellor Angela Merkel moved to quickly phase out all of the country's nuclear power plants. The French government also enacted legislation to cut the use of nuclear power by 1/3 by 2025.[66] At the same time, China and India remained committed to expanding the contribution of nuclear technology within their borders. Figure 1.3 shows the commercial nuclear reactors in India in operation as of the writing of this dissertation, two of which connected to the grid in the post-Fukushima era.[67] Figure 1.4 shows nuclear reactors under construction or planned for India through the year 2020.[68] It should be noted that points in the future in Figure 1.4 represent multiple reactors at one site—the Nuclear Power Corporation of India Ltd. (NPCIL) currently assigns one expected project start date to all reactors at a given site. The numbers in parentheses indicate the actual number of reactors associated with each of those points.

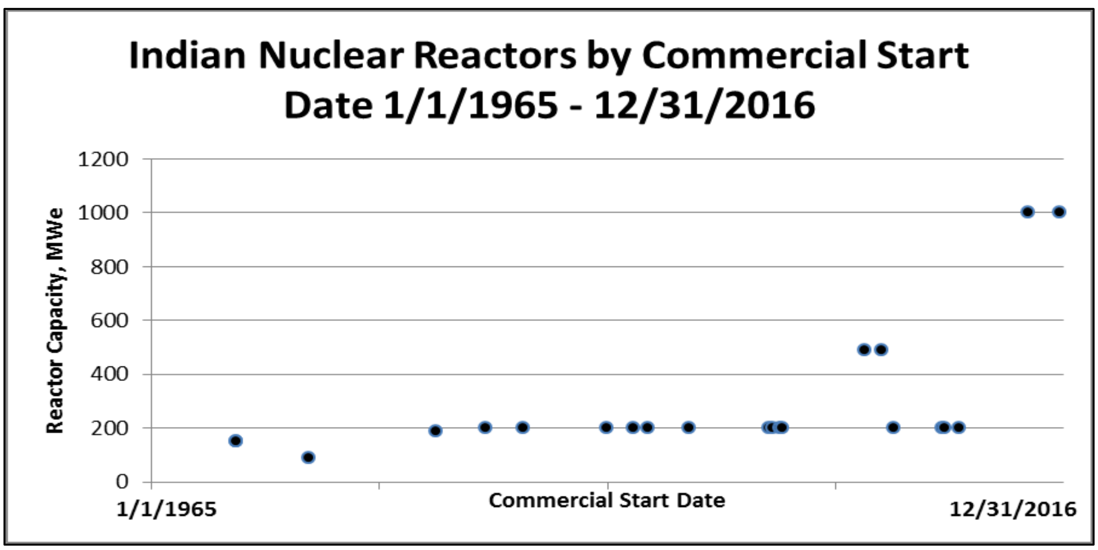

Figure 1.3 Indian Nuclear Reactors in Operation

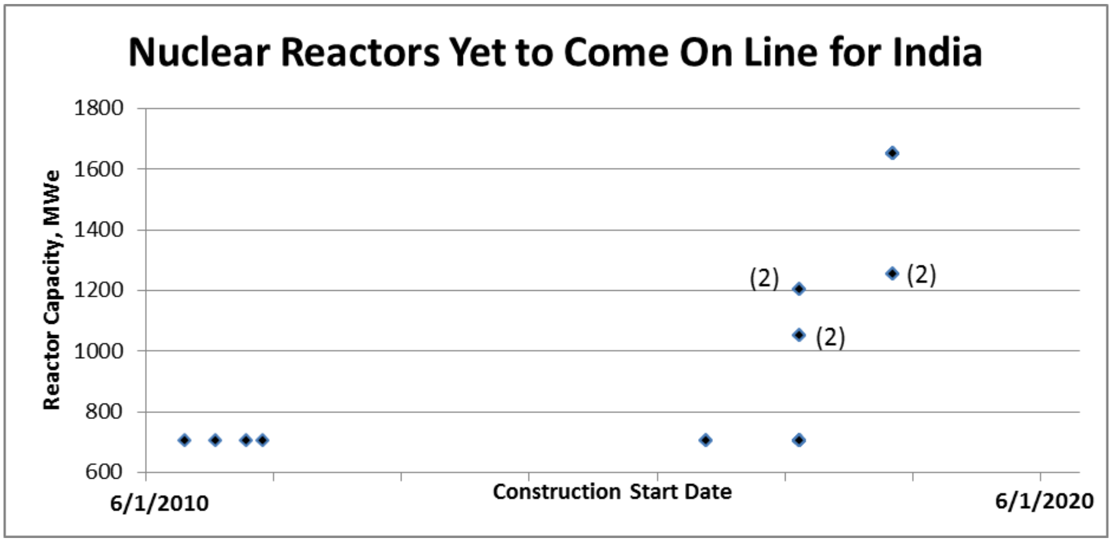

Figure 1.4 Nuclear Reactors Yet to Come On-Line for India

Although nuclear technology experts and some environmentalists argued in favor of nuclear power as a clean, green technology with low levels of carbon dioxide, sulfur dioxide, or nitrogen oxide emissions, concerns about the safety of aging reactors, spent fuel waste disposal, the long lead times for construction and high costs of new reactors have continually plagued the commercial nuclear business. While work is under way on two reactors in Georgia and another two in South Carolina, four reactors in the United States have closed since 2013 and another ten are at risk of closure due to safety and reliability concerns, the lower costs of alternative energy sources, and changing regulation.[69] Instead of building domestically, American, French, Japanese, and Russian companies now export their once tightly held technology to China, India, South Korea, Niger, Namibia, and elsewhere.

1.2 Summary and Moving Forward

This brief review of the history of nuclear technology has demonstrated that the structure of the modern nuclear industry had its roots in the military, political and scientific concerns of the 1940s and 1950s. Maintaining tight control over information and defending employees and the public from the workings of the technology were paramount. Layers of agencies, commissions, and organizations then assumed responsibility for the commercial development of nuclear technology. Those groups had to deal with issues of reactor safety, the escalating costs and complexity of nuclear reactors, and deciding how much information to share with the public. The reactor core meltdowns in Japan again raised questions about the safety of aging reactors and untried emerging reactor designs. It also brought the impact of a nuclear accident to the world's attention more openly and with more immediacy than before: People employed by Tokyo Electric Power Company (TEPCO) fought valiantly to save the crippled reactors, local farmers and villagers fled the contaminated countryside, schoolchildren lined up for radiation checks, and the usually reserved Japanese turned out in thousands to protest the restart of the country's nuclear power stations. Even so, decision-makers in countries of the global south are choosing to invest in nuclear technology.

The chapters that follow examine nuclear technology and the related displacement from a more theoretical point of view. Chapter 2 explores a Socio-Political Ecology framework for understanding the interplay of politics, economics/demand for electricity, environmental concerns, and society in making decisions about technology. Chapter 3 delves into the development of the Process Model of Displacement. The chapter explores the concept of "place" and the attachments people form with their place. Those attachments derive from experiences with place, from emotional ties, from the social support associated with their place. As a result, displacement becomes much more than the loss of a dwelling. The methodology used to explore the Socio-Political Ecology of nuclear technology and the Process Model of Displacement is outlined in Chapter 4. The next three chapters review the context of the three case studies and demonstrate the value of the Socio-Political Ecology framework for understanding the similarities and differences in the circumstances at the Hanford Nuclear Reservation, Chernobyl Nuclear Power Plant, and proposed Jaitapur Nuclear Power Plant. Chapter 8 pulls from those three case studies to illustrate the Process Model of Displacement. Interviews and oral histories exemplify the displacement that occurs throughout the life cycle of a nuclear technology project. Final thoughts and ideas for extensions of this research are presented in Chapter 9.

ENDNOTES

[1] Chernobyl is the Russian spelling of the site of the 1986 catastrophe; Chornobyl is the Ukrainian spelling. Likewise, Pripyat is the Russian spelling of the town north of the nuclear power plant; Prypiat is the Ukrainian spelling. Russian spellings will be used throughout this document, because the accident occurred while Ukraine was part of the Soviet Union and Russian was the official language. However, some quotations and citations do incorporate the Ukrainian spellings of the names.

[2] Bertrand Goldschmidt, *The Atomic Complex: A Worldwide Political History of Nuclear Energy* (La Grange Park, IL: American Nuclear Society, 1982), 7.

[3] Heavy water reactors use natural uranium and deuterium oxide (D_2O) as a coolant and moderator. During WWII, Germany produced deuterium oxide in Norway. Sabotage of the heavy water production served as a form of resistance to Germany's invasion of Norway (Gunnar Sonsteby, *Report from No. 24* (London: Collins Clear-Type Press, 1965).

[4] History and Heritage Committee, The American Society of Mechanical Engineers, Columbia Basin Section, *Hanford B-Reactor* (Richland, WA: The American Society of Mechanical Engineers, May 1976), 9.

[5] Ibid., 5.

[6] Goldschmidt, 27.

[7] Ibid., 71.

[8] "Treaty on the Non-Proliferation of Nuclear Weapons," United Nations Office of Disarmament Affairs, Treaties Database, accessed June 25, 2016, http://disarmament.un.org/treaties/t/npt.

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Testing in Australia," in *Wayward Governance : Illegality and its Control in the Public Sector* (Canberra : Australian Institute of Criminology, 1989), 235 – 253.

[10] Goldschmidt, 138, 139.

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[13] Kate Brown, *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters,* (New York: Oxford University Press, 2013), 79 – 80, 117 – 119.

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[16] Goldschmidt, 52.

[17] Steve Cohn, *Too Cheap to Meter: An Economic and Philosophical Analysis of the Nuclear Dream* (Albany, NY: State University of New York Press, 1997); Steven L. Del Sesto, *Science, Politics, and Controversy: Civilian Nuclear Power in the United States, 1946 – 1974* (Boulder, CO: Westview Press, 1979).

Note that in 1974 the oversight and regulatory responsibilities of the U.S. AEC would be given to the Nuclear Regulatory Commission (NRC) whereas the energy research and development functions fell under what is now known as the Department of Energy (DOE).

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[20] Goldschmidt, 289; “The Nuclear Energy Agency,” Accessed June 27, 2016, http://www.oecd-nea.org/general/about/.

[21] David Fischer, *History of the International Atomic Energy Agency, the First Forty Years* (Vienna: The International Atomic Energy Agency, 1997), 19.

[22] Ibid., 20.

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[24] Hagerty, 35 – 36.

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[26] Nuclear Service, French Embassy in Washington, “Nuclear Power in France,” July 2013, http://www.ambafrance-us.org/IMG/pdf/Nuclear_power_in_France.pdf.

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[29] See Brown’s *Plutopia* for a description of one such city: Ozersk, Russia.

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[31] Oladapo Awosika, “The Windscale Nuclear Accident: Could it Have Been Avoided?” University of Dundee, Centre for Energy, Petroleum and Mineral Law and Policy, accessed June 28, 2016, www.dundee.ac.uk/cepmlp/gateway/files.php?file=CAR-12.

[32] U.K. Atomic Energy Authority, *A Revised Transcript of the Proceedings of the Board of Enquiry into the Fire at Windscale Pile No. 1, October 1957* (1989), 8.11.

[33] See also Kathleen M. Saul and John H. Perkins, “Nuclear Power: Is it Worth the Risks?” in *Green Energy Economies: The Search for Clean and Renewable Energy,*

ed. John Byrne and Young-Doo Wang (New Brunswick, New Jersey: Transaction Publishers, 2014), 278 – 279.

[34] U.S. Nuclear Regulatory Commission, “U.S. Nuclear Reactor List—Operational,” Data Released November 2004.

[35] U.S. Nuclear Regulatory Commission, “Pressurized Water Reactors,” January 15, 2015, https://www.nrc.gov/reactors/pwrs.html.

[36] World Nuclear Association, “Nuclear Power Reactors,” February 2017, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/nuclear-power-reactors.aspx.

[37] U.S. Nuclear Regulatory Commission, “Boiling Water Reactors,” January 15, 2015, https://www.nrc.gov/reactors/bwrs.html; World Nuclear Association, “Nuclear Power Reactors.”

[38] U.S. Nuclear Regulatory Commission, “Pressurized Water Reactors”; U.S. Nuclear Regulatory Commission, “Boiling Water Reactors.”

[39] Based on data contained in the U.S. Nuclear Regulatory Commission, “U.S. Nuclear Reactor List—Operational.”

[40] Saul, 18 – 23; Steve Trotter, former electrician at the Hanford Nuclear Reservation, Executive Director Operations, Budget and Planning, The Evergreen State College, Interview with the author, The Evergreen State College, Olympia, WA, February 18, 2016; Robin Cantor and James Hewlett, “The Economics of Nuclear Power: Further Evidence on Learning, Economies of Scale, and Regulatory Effects,” *Resources and Energy* 10 (1988): 315 – 335.

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[48] Saul and Perkins, 280.

[49] World Nuclear Association, "Early Soviet Reactors and EU Accession," July 2013, http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/appendices/early-soviet-reactors-and-eu-accession.aspx.

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21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," U.S. Nuclear Reactor Commission (July 12, 2011): 69 – 70.

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[68] World Nuclear Association, "Nuclear Power in India."

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Chapter 2

A SOCIO-POLITICAL ECOLOGY FOR THE ANALYSIS OF NUCLEAR TECHNOLOGY DISPLACEMENT

The first chapter of this dissertation reviewed the history of nuclear technology, the events and conditions that laid the foundation for the industry as it exists to this day. This chapter takes the key elements of the industry and places them into a more theoretical framework--Political Ecology. It also argues for the addition of a new dimension to that model, a social dimension. Adding this new element underscores the impacts decisions about the choice of and use of nuclear technologies has on people, impacts that could include the loss of livelihoods, access to traditional resources, or homes and land that have been in families for generations.

2.1 Political Ecology Becomes Socio-Political Ecology

Political Ecology first emerged in the 1970s to help explain the interconnections between the natural environment, political and economic factors.[1] Those in the field attempted to understand environmental degradation as more than the inevitable result of growing populations; they investigated how the politics of access to and control over natural resources affected environmental conditions. They also looked into the management of environmental problems. As explained in more detail in Appendix A, scholars like Blaikie and Brookfield (1987) and Greenberg and Park (1994) more formally identified Political Ecology as a synthesis of political economy (concerned with the distribution of power and productive activity) and ecological analysis (which examined bio-environmental relationships).[2] Perkins later used the

Political Ecology framework to explain how technology can mediate between human want and needs and the environment/natural resources.[3] In that vein, electrical production technology provides communities with access to entertainment gadgets (radio, television, iPod), work devices (computers, printers), and appliances (dishwashers, washing machines, air conditioners) by transforming natural resources such as coal, natural gas, water, or uranium ore into usable forms of kinetic energy.

When used to examine nuclear technology in particular, an expanded Political Ecology model underscores the relationships between 1. Economic factors (such as the need for government, insurance, or rate payer subsidies to finance plant construction due to the high costs, and the need for owners to generate profits over the lifetime of the investment); 2. Concerns about the safety or risk associated with nuclear technology (discussions of risk associated with nuclear technology usually focus on the chance of exposure to radiation or a core meltdown in a nuclear reactor, but could also include investment risk); 3. Natural resources and environmental issues (concerns about long term storage of radioactive wastes as mentioned in Chapter 1, as well as the impact of mining, milling, conversion, and enrichment of uranium ore); 4. Available nuclear technologies; and 5. The political and policy climate that serves as the backdrop for all of those factors.[4] These factors are shown in Figure 2.1.

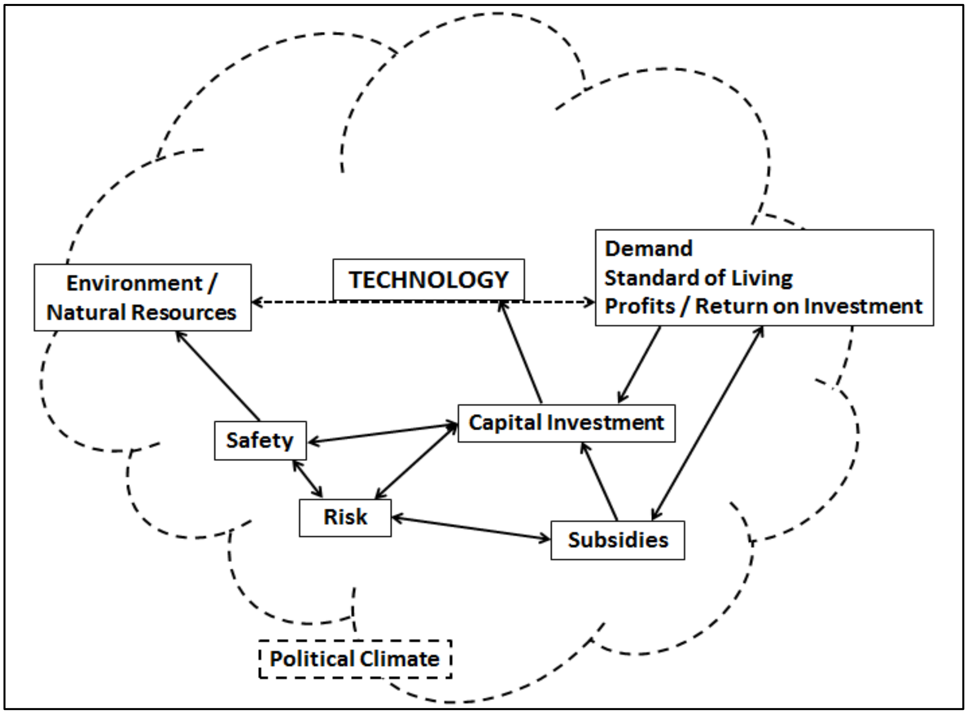

Figure 2.1 The Political Technology of Nuclear Technology

The solid uni-directional arrows in Figure 2.1 reflect the one way nature of those particular influences while all of the double-headed arrows imply the potential for two-way influence. For example, the dashed, double-headed arrow under "Technology" shows that technology mediates between the demand for the output of the nuclear facility (in the case studies examined later, either electricity or plutonium), the expected standard of living, or a utility or energy company's desired return on investment / profit levels, and nature (environmental resource inputs or the impact of technology upon the environment). The double-headed arrow connecting risk and subsidies reflects the fact that because of the level of perceived risk associated with nuclear technology, the U.S. government had to offer loan guarantees and an extension of the Price Anderson Nuclear Industries Indemnity Act (which caps the liability for commercial nuclear power plant operators in case of nuclear accident) before utilities or energy companies could obtaining financing for their proposed new nuclear power plants. While these subsidies did not affect the operational risks associated with nuclear power, they did bring down the investment risk for Wall Street banks, and thus the ability of utilities or energy companies to access capital for their investments (the solid, uni-directional arrow in Figure 2.1).

Unfortunately, neither the original Political Ecology framework nor the one presented above explicitly reflects the impact of nuclear technology decisions on *people*. Of particular interest for this dissertation, people get displaced to make way for large scale nuclear power facilities. No component in Political Ecology represents the people who lose their homes, their lands, and their livelihoods because of the construction of nuclear power plants or as the result of accidents at nuclear facilities. The framework cannot capture the 1,500 residents of the farming towns of Hanford, White Bluffs, and Richland, Washington who received notices to evacuate their homes within 15 – 90 days when the U.S. Army decided to build the Hanford Nuclear Reservation in eastern Washington in 1943.[5] Political Ecology also fails to account for attachments those people might have developed to their homes, to the places their parents homesteaded and where they grew up. Nor does it consider that people had to be uprooted and make new lives in Pripyat, the town erected to house the workers at the Chernobyl Nuclear Power Plant, or the new attachments formed by the 45,000 or so who trekked to the Washington desert to find jobs and establish new communities at the site. Political Ecology does not have any component to represent the strong ties to a homeland that drew pensioners back to the Chernobyl Exclusion Zone after the catastrophic nuclear accident of 1986. The framework also lacks a factor that reflects the concerns of the fishermen from Sakharinate, Maharashtra, India who fear the impact of releases of nuclear power plant cooling water on the fishing grounds they now frequent, the only fishing grounds they have ever known. In essence, Political Ecology fails to account for the myriad of effects of nuclear technology projects on the people.

Figure 2.2 below illustrates a new Political Ecology model that incorporates that "people" element, a Socio-Political Ecology Model.[6] It reflects the fact that technology choices not only mediate between human wants and needs and the natural environment, but also affect and are affected by dimensions of the social environment. Double sided arrows, indicating the possibility of two-way flows of influence, link the social environment to technology choices, environmental and natural resource issues, and the economics of particular investments. Issues of human health and safety related to nuclear technology also impact people's ability to remain in their homes after significant radiation releases (as was demonstrated after the Chernobyl, Ukraine accident in 1986 and again at Fukushima Dai-ichi, Japan in 2011) and influences their perceptions about the safety of nuclear power, as indicated by the arrow from Safety to the newly added dimension.

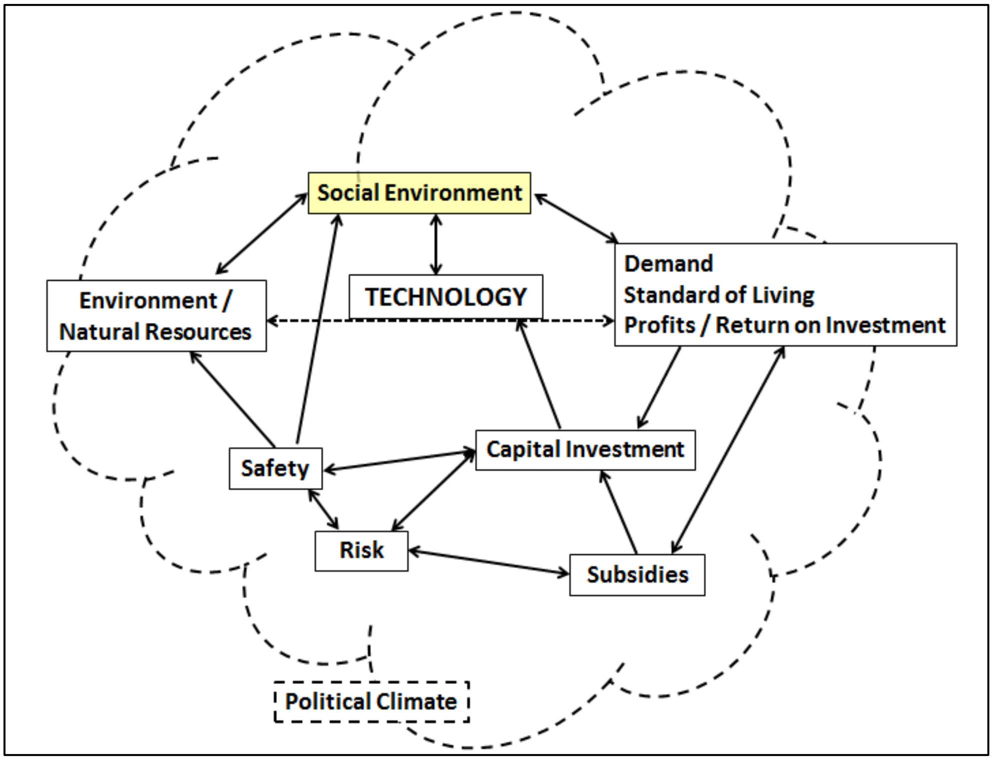

Figure 2.2 A Socio-Political Ecology

Bundling Subsidies, Capital Investment and Demand/Standard of Living/Profits/Return on Investment into a more general Demand/Economic factor, and by merging Safety and Risk into one factor, Figure 2.2 can be depicted as more generally as shown in Figure 2.3 below.

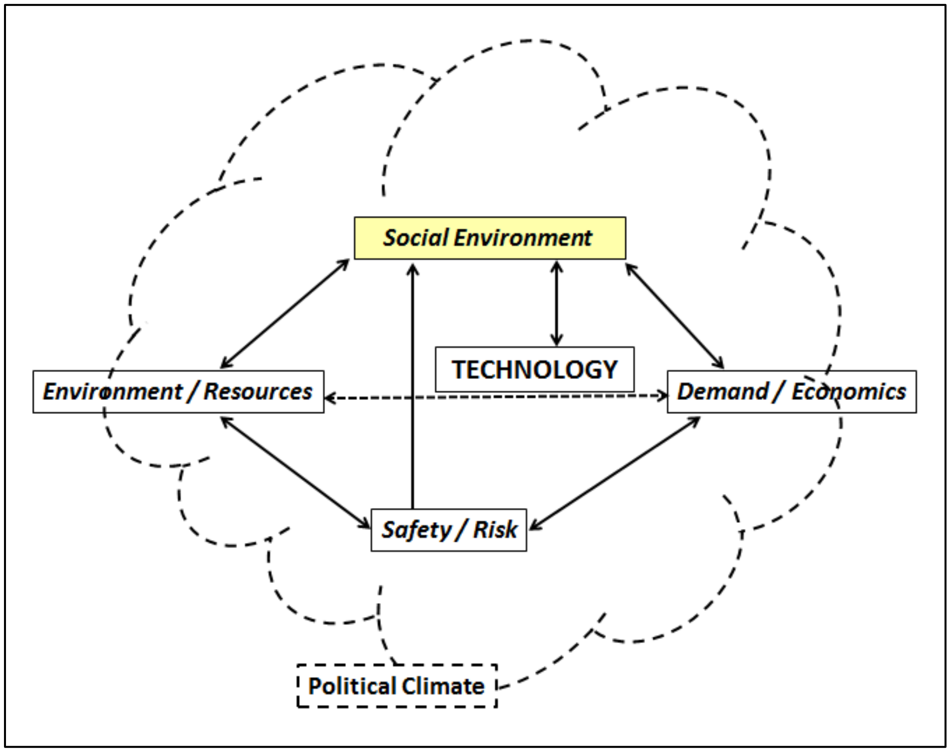

Figure 2.3 A General Socio-Political Ecology

As was hinted at in the previous paragraph, an aspect of the social environment of particular interest for nuclear technology is displacement. Displacement has occurred most visibly as the result of nuclear catastrophes, when tens of thousands of people have been forced out of the homes in very short time periods by potentially lethal levels of radiation. The scale and scope of these mobilizations make them difficult to ignore: Soviet officials evacuated over 135,000 people from the 30-km zone around the crippled Chernobyl Reactor 4;[7] 185,000 were evacuated within two days after the earthquake and tsunami crippled the Fukushima Dai-ichi power plants.[8] Displacement also occurs when the original inhabitants of the land chosen for a nuclear facility need to leave to make way for the construction, when crews of construction workers and tradesmen relocate to the site to build the facilities, when plant operators replace construction crews, and even after the facilities have closed and efforts commence to decommission the site (as occurs for shuttered commercial reactors) or cordon it off from the public (as has happened in the case of the Hanford Nuclear Reservation and the Chernobyl Nuclear Power Plant). The section that follows reviews the literature on displacement to provide background on the subject and an appreciation of how displacement has been and is being treated by scholars.

2.2 The Literature on Displacement

Displacement occurs when people are forcibly removed from their "place," often involuntarily, as in the case of war/conflict, environmental disasters, or infrastructure projects such as road systems or irrigation canals. As far back as the colonial era, people around the world were displaced (and re-placed) to make way for large scale agricultural plantations, factories, and infrastructure to support the growing demand of the European capitalist consumer.[9] Theorists have long acknowledged the displacement associated with modern life. During the Industrial Revolution, families seeking employment at the new textile factories moved from their pastoral lands into the newly formed villages and cities.[10] Karl Marx provided one of the first published statements about displacement on a large scale in his discussion of primitive accumulation, the enclosure of land, and the displacement of peasants in *Capital* (1867).[11] Authors like Arturo Escobar have argued that displacement forms an integral part of the Western capitalist notion of modernity. That pattern continues as institutions search the globe for raw materials, supplies of energy, and outlets for finished goods. Indeed, many in the developed and developing world view the expansion of capitalistic development-oriented systems and their adoption world-wide (i.e. "globalization") as a sign of progress.[12] Displacement, then, becomes an unfortunate consequence of that progress.

Following in the footsteps of John Stuart Mill and Utilitarianism, governments, financiers, and engineers tend to justify large scale development as providing the greatest good for the greatest number of people. In one example, planning for the harnessing of the Narmada River in India for irrigation and electricity generation began in the 1940s, shortly after Indian independence. Even in the early stages of project design, it became clear that almost 300 villages would be submerged in the reservoir behind the largest dam of the system, the Sardar Sarovar. However, the World Bank estimated the number of beneficiaries of the water and power from the dam at over 100 times the number that would suffer because of it.[13] The water would allow crop production in Gujarat that would feed 20 million people and would supply industries that would employ one million. Those displaced by the dams should receive compensation for loss of their land, homes, and businesses. Even so, the economic benefits from the project were deemed to far outweigh its costs. Similar scenarios have played out across the developing world.[14]

As the Senior Advisor for Social Policies and Sociology for the World Bank, Dr. Michael Cernea investigated the issue of displacement and resettlement associated with development policies and projects. He published his "Risk and Reconstruction Model for Resettling Displaced Populations" in 1997.[15] Based on data gathered over 15 years of study of resettlement, he proposed that without conscious intervention, displacement and resettlement usually leads to poverty. The key causes of that poverty include:

1. Landlessness and the associated loss of productive capacity or food sources

2. Joblessness

3. Homelessness

4. Marginalization due to the loss of social status, economic power, and de-skilling that accompany moving to a new place

5. Increased likelihood of illness and morbidity

6. Food insecurity and malnutrition

7. Loss of access to common property resources such as water bodies or grazing lands; and

8. Social disarticulation—the destruction of the kinship ties and informal support networks that help rural populations weather periods of crisis.

Cernea argued that despite the use of cost-benefit analyses to justify projects, and despite some attempts to compensate people for their losses, project sponsors never fully take into account the long-lasting social costs of the projects. Furthermore, when social costs do factor in, those doing the analyses fail to recognize that the people receiving the benefits from development projects likely are not the same as the people bearing the costs.[16] Rather than just providing monetary compensation, Cernea supported an approach that would restore and even enhance the income generating potential of those displaced. He also advocated the inclusion of all relevant stakeholders in formulating plans over a top-down approach to decision-making.[17]

Many contemporary researchers have drawn on Cernea's Risk and Reconstruction Model in their explanations of the displacement and ensuing social problems related to development projects. Bennett and McDowell, for example, in *Displaced: The Human Cost of Development and Resettlement*, looked into the upheaval resulting from the expansion of coal mining, agricultural production, and the construction of large dams, in India, Pakistan, Kenya, and Lesotho.[18] Like Cernea, they concluded that a process of informed consent of the affected communities is essential if already marginalized people are to have some control over the process that takes so much from them. In most cases what has been lost includes not only land and livelihoods (things which can be monetized and put into benefit-cost calculations), but also supportive social and kinship relationships, trust, the familiarity with the place, and a sense of community and order—things for which no amount of money can compensate.

Agrawal and Redford critiqued the Cernea model in the introduction to a special issue of *Conservation and Society* (2009) devoted to displacement associated with the creation of conservation and protected areas.[19] They argued that the model failed to incorporate the interactions among the different types of risks, and that the focus on the economic risks to livelihoods fails to consider the political, ethical, and human rights issues that also come into play. This theme appeared in other articles in that issue as well. Krueger contended that more regions and countries need to adhere to the existing international laws and guidelines regarding the use of displacement only in rare circumstances and the involvement of indigenous peoples in decision-making.[20] Bray and Velazquez cited evidence from Mexico, where bottoms up, community based forest management had led to a "benign impact on migrant and resident bird species" and where logging by indigenous communities in the Amazon Basin was found to have little effect on habitat structure or seed predation.[21] People and "protected" places could co-exist.

A more recent line of inquiry looks at the displacement associated with global climate change.[22] In this case, the choice to employ technologies that burn fossil fuels (automobiles and coal fired power plants, to name just two) has led to the release of carbon dioxide, methane, and other greenhouse gases into the atmosphere. Those gases have trapped heat, resulting in an average 1.4 ^{o}F increase in the Earth's temperature over the last century.[23] Not acting to curb the burning of fossil fuels at a global scale means that severe storms and flooding, melting of glaciers and polar ice caps, and sea level rise, heat and extreme droughts have forced and will force millions from their land and their homes.

Interestingly, those closest to the land, those whose lives are most intimately entwined with nature, the indigenous peoples, are also those with first-hand experience with the effects of climate change in their regions.[24] For the Native Americans of Alaska, alterations in animal migration patterns now impact subsistence food supplies. The people of Kivalina and other coastal villages must move inland as thawing permafrost and rising sea levels imperil their land.[25] Changing climate has diminished the ability the Maori of New Zealand to use traditional methods to predict weather patterns:

> When we were growing up our old people could tell three weeks in advance what the weather was going to be like, from the cycles of the moon and from the appearance of the moon and sun. We had other methods of knowing weather patterns. For example, when we gutted blue cod, if they had stones in their belly, we knew that bad weather was coming. The cod swallowed stones to give them ballast so they would not be thrown around as much by the swell… I can still tell the weather using the old ways but with far less reliability.[26]

South Pacific Islanders already have been displaced by the salinization of fresh water supplies and rising seas.

Whether the result of economic development, conservation and species protection efforts, global climate change, or other factors, displacement--the removal of people from their homes and their sources of livelihoods, from their "places"--results from the complex interplay of environmental factors; technology choices; laws, regulations, and power relationships; the political climate; and economic analyses (the elements of the Political Ecology model). While it is impossible to gauge the exact number of people displaced by nuclear technology projects each year, we do know that as of April 2016, 60 nuclear reactors were under construction in 13 countries and Taiwan.[27] About 5,000 people are working to build the first two new nuclear reactors in the United States in decades (Georgia Power's Plant Vogtle).[28] Extrapolating that figure leads to about 150,000 nuclear construction workers worldwide—as compared to the estimated 135,000 evacuated from Chernobyl's 30 km exclusion zone in 1986. Thus, on the basis of sheer numbers of people affected, displacement caused by nuclear projects cannot be ignored.

The literature on displacement reviewed in this chapter has provided an idea of its effects on people, however, that literature does not investigate the reasons why displacement can be so disrupting, why people resist being moved, and why monetary compensation for land and livelihoods lost may not be sufficient. To better appreciate the complex issues surrounding displacement we must understand place and people's attachments to place that precede displacement. Those are the subject of Chapter 3.

ENDNOTES

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[6] In 1997, Frederick L. Bates published a volume entitled *Sociopolitical Ecology: Human Systems and Ecological Fields* (New York, NY: Plenum Press). In it he offers a point of view that puts human systems on equal footing with biological systems (xv). It argues for the relevance of social sciences to the ecological and biological sciences and vice versa and the interdependencies among them (227). While there may be similarities in the titles of the perspectives, they emerged independently, evolved along different trajectories, and are used to explain different phenomena.

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[17] Ibid., 1580.

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Chapter 3

A PROCESS MODEL OF DISPLACEMENT

Poets, novelists, dramatists, and lyricists have sung the praises of “home.” They have captured our imaginations with descriptions of places like the plantation at Tara (*Gone with the Wind*), the farm back in Kansas (*The Wizard of Oz*), favorite cities (“New York, New York”; “Bonjour Paris!”) or homes left behind (in the poetry of Lucy Maud Montgomery, Robert Frost, and Walt Whitman). Many people feel a reverence of, a fondness for, an attachment to, or perhaps even a strong dislike for particular locations they have encountered in their lives. It is not possible to truly understand displacement and its impacts without deeper appreciation of “place” and people’s emotional responses to and the bonds they forge to places. Thus, as indicated in Chapter 2, this chapter explores further the concept of place as well as attachments to place and communities. The chapter redefines displacement in terms of disruptions to place attachment. It then moves beyond the conception of displacement as an event that occurs when people are forced to leave their homes and livelihoods, and introduces a new approach to thinking about displacement particularly as it relates to nuclear technology, a process model of displacement.

3.1 Place and Place Attachment

3.1.1 How is “Place” Understood?

In the 1970s, Yi-Fu Tuan, pioneered studies of peoples’ attachments to “place.” His books *Topophilia: a Study of Environmental Perception, Attitudes, and*

Values and *Space and Place: The Perspective of Experience*, explain how people use their senses to come to know their physical surroundings.[1] People get to know those surroundings, attaching memories and feelings to them. Personal experiences give those surroundings value. As Tuan described, undifferentiated space becomes "place."[2] The more ties there are to a place, the more experiences and memories that are associated with a place, the deeper the connection to it. Emotions and social relationships, feelings and cultural beliefs, not biological necessities, connect people and place.[3] Attachment to place brings with it a sense of continuity in place, a feeling of security, a rootedness not experienced by other creatures.

Relph, building on Tuan's work, explained that place consists not only of a physical location, but also of the attributes of that location, the objects housed there, or the functions the location serves.[4] A location becomes place through individual interactions with it and knowledge of it. A location becomes place when individuals imbue it with meaning and acquire memories of experiences associated with it. Thus, place involves psychological and emotional relationships with a location, not just a description of its tangible characteristics.

Each person experiences a location through his or her own set of lenses, lenses derived from personal values, beliefs, and attitudes that color what they see, how they react, and how they interpret their experiences with that particular location. In this respect, no two places are exactly the same. However, people often share a common location, a common piece of ground. Common experiences and involvement with that piece of ground can infuse it with communal meanings, a "collective place consciousness."[5] The soaring Gothic cathedrals of Europe and vibrantly colored intimate Hindu temples of India, for example, have acquired one set of place meanings for the individuals who worship there, and quite a different set of meanings for the larger community that views them as interesting examples of architecture or relics of ages past. In addition, because one location may be experienced in a variety of ways over time, it becomes a repository of the events and attitudes of the past as well as those of the present--it has historical as well as contemporary significance. Place then is a multifaceted phenomenon with physical and cognitive, individual and communal, and temporal dimensions.

The complexity of place has been captured in the variety of definitions provided by scholars in the decades since the publication of the works of Tuan and Relph. Altman and Low describe place as space that has been given meaning through personal, group, and cultural processes.[6] Cuba and Hummon added boundedness to that definition of place—place is a *bounded* locale to which people have emotional ties and for which there is a sense of shared interests and values.[7] Those same characteristics factor into the definition provided by Escobar: place is the "experience of a particular locale with some measure of groundedness (however, unstable), sense of boundaries (however, permeable), and connection to everyday life, even if its identity is constructed, traversed by power, and never fixed."[8] Groundedness gives people a feeling of belonging in a specific location, in a neighborhood perhaps, or a hometown. They know the people who live in their place, the streets and buildings, or fields and animals; a sense of routine permeates daily life. Life becomes predictable and safe within the boundaries of that place. But those boundaries can be traversed. Over time, people come and go, relationships with people change, physical settings deteriorate and get rebuilt, and new structures get added. The spheres of peoples' interests and activities also expand and contract. Meanings attributed to locations may be modified as new events and experiences come to be associated with that location. In one example, a statue of Vladimir Lenin in Kiev, Ukraine, a statue which once symbolized the power of the Soviet Union and Ukraine's former position as a Soviet Socialist Republic, came toppling down in December 2013 as Ukrainian protestors sought to reassert their country's independence and rid themselves of the oppression of Russia, as symbolized by that very image of Lenin.[9] The protestors no longer welcomed Lenin and the power of Moscow (the power that built the Chernobyl Nuclear Power Station and neighboring Pripyat) in Kiev.

Note that as meanings change and people change, place itself changes. Place changes because it is intimately connected with the thoughts and actions of day-to-day life. It is not rigid and inflexible. Place is fluid and evolving.

Many scholars link place and a person's self-identity. Place provides the sense of being at home and of belonging, the feelings of safety and security that people need when developing their own ideas and interpretations of the world around them.[10] Manzo's interviews with U.S. residents living in New York's Manhattan area revealed that places people deemed significant were those providing space for introspection, reflection, and privacy; and those offering safety, comfort, and an absence of threat.[11] Those places allowed people to form and reform their identities. Those places allow them to understand who they are, what they stand for, the groups to which they belong or do not belong, the people who influence them, and how they feel about themselves. Unexpected changes to such places can force a person to re-examine their identity, to adjust that identity as necessary, or to find a new place better suited to them.[12]

3.1.2 "Sense of Place" Defined

Another subject closely related to place is "sense of place." Sense of place emerges over time as an individual interacts with a location and comes to understand its cultural, historical, and social significances. [13] A person becomes aware of the qualities of the place that other people value, the symbolism attached to monuments, and the meaning of various rituals in which they have participated. According to Hay and Hummon, sense of place encompasses the subjective interpretation of both the tangible and intangible aspects of a location and the emotions tied to them.[14]

Although sense of place is very much an individual, personal sentiment about a location, a community level sense of place may also develop as people engage in shared experiences and adopt a shared system of beliefs. For many, lengthy residence or ancestral connections to the location strengthen the community sense of place.[15] Community sense of place can then dictate the types of behaviors and activities that are appropriate or inappropriate in that place. Community sense of place lets people know where they can run and shout and play, and where they must bow their heads in reverence. However, not every community bestows the same meanings and significances on a given location and that can lead to conflict. The San Francisco Peaks in Arizona, for example, have religious significance for 13 Native American tribes. The Navajo, Hopi, Hualapai, Havasupai and Apache tribes consider the Peaks the most sacred in the entire West. Navajo medicine men travel there to gather herbs and hold healing ceremonies. But over the past 10 – 20 years this Native sense of place has been shattered by the expansion of the Arizona Snowbowl ski area (which included clearcutting an additional 74 acres) and the use of 100% reclaimed wastewater (treated sewage) for snowmaking.[16] In the courts, the people with a sense of place based on personal enjoyment of skiing and the economic revenues of the sport, have won out over those with the spiritual connections at the San Francisco Peaks.

Relph and others might describe the conflicts over the San Francisco Peaks as disagreements between "insiders" and "outsiders."[17] "Insiderness" comes with "knowing where you are," being content, and being surrounded by a familiar place, not being a stranger to it.[18] Insiderness means belonging to and identifying with the place. "Outsiderness," on the other hand, can be characterized by a dispassionate attitude or even an alienation from the place. Place becomes merely a backdrop for activities, a location visited but not one that is intimately interlinked with one's self-identity. In the case of the San Francisco Peaks, the Native Americans can claim the insider position. The Peaks are home to Talking God, White Corn Boy, Yellow Corn Girl, Abalone Shell Boy and Girl, and other ancestors. To the Navajo, the Peaks represent life.[19] "If we can't practice our religion, preserve our traditions, we'll lose our identity," (Klee Banally, Navajo Activist).[20] Skiers and snowboarders, investors in the Arizona Snowbowl, even the U.S. Forest Service (which approved the Snowbowl expansion project) can be considered "outsiders." Their experience lacks the depth, the spiritual and emotional connection that can be found among the Native Americans. They can leave that place and not lose themselves.

Status as an insider or outsider and the difference in intensity of attachment to place can also influence place-related behaviors. As in the case of the San Francisco Peaks and the Arizona Snowbowl, powerful outsiders can be viewed as a threat to place and can bring about defensive, place protective actions.[21] People may engage in letter writing campaigns, protest marches, blockades, or legal actions in an effort to protect their place. Indeed, research has shown that those with stronger emotional bonds to a location and those for whom a location forms an integral part of their identity often have a greater willingness to take action on behalf of that location.[22] People with weaker ties find it easier to find other locations to live, work, and recreate.

Outsiderness may also be experienced by people who have been displaced to make way for wildlife preserves, hydroelectric dams, or large nuclear projects. The displaced may speak a different language, have different dietary habits, and practice a different religion from the people in the location they now inhabit. Many that move to densely populated urban areas lose their identity and the status they once enjoyed in their villages. That status means nothing to their new neighbors.[23] Family history cannot be recreated in the new place. Nor can certain ways of life. For example, traditional healers in Lesotho, Africa lost access to fever bush (*Dicoma anomala*--used to treat coughs and fever) and milk bush (*Xysmalobium undulatum*—used to relieve headaches and indigestion) when moved to urban areas to make way for the Mohale Dam. As a result, they lost not only their occupation but also their prestige in the community.[24] People who lost land to coal mines in India lamented, “We worship nature but when nature itself does not survive, how can there be any prayers? The biggest harm that the colliery has done is that we [are] losing our own identity.”[25] As indicated earlier, fishermen near the proposed Jaitapur Nuclear site fear access to their fishing grounds will be blocked by security at the nuclear power station.[26] They express concern that the fish will no longer frequent the waters due to hot water releases, increased light and boat traffic in the area. They cannot take their fishing vessels elsewhere since fishing grounds have been identified geographically along the coast. Jaitapur fishermen would not be welcome in other localities.[27] They would be outsiders.

Sense of place can be negative for people exposed to the violence of war or domestic violence and for those who feel trapped by circumstances and unable to leave. A "poisoned sense of place" also develops when excessive passion for local or national identity or ethnicity leads to ideas of exclusivity, supremacy, and treating others with contempt or hatred.[28] Some people who have resided in a place for a long time might find their ties weakening as they sense a change in values. People new to the area might not feel accepted if they do not accept the newly established norms. A poisoned sense of place can emerge informally, may be codified as in neighborhood by-laws, or may result in acts of terrible violence, as witnessed in Nazi Germany, Bosnia, Rwanda, and other places.

3.1.3 "Place Identity" Explained

Proshansky, Fabian, and Kaminoff describe place identity as a subsection of self-identity. "Place identity" consists of the memories, feelings, attitudes, values, preferences, perceptions, and insights that relate to a physical location.[29] Like self-identity, place identity emerges from direct experiences with a location. It can be transformed by the characteristics, beliefs, and values associated with each individual or each group—it is both a personal and a community construction. In fact, Tuan contended that place identity resulted from distancing oneself from a location, reflecting on it, thinking and talking about it with others.[30]

Like self-identity, place identity can change over time with changes in individual experiences or changes at the societal level (such as advances in technology or economic turmoil). Place identity serves as the locational past that allows people to understand the importance of a particular location for them. It serves as the benchmark against which people compare their new experiences and thus determine the degree of congruence or continuity. Only when a wide discrepancy exists between the identity accorded a location and the location itself do people become aware of place identity and then take steps either to avoid that location or to make changes in it to bring the perceived identity and the reality back into agreement. For example, early residents have been troubled by the transformation of the Tri-Cities area of Washington from small company towns whose fortunes depended on those of the nearby Hanford Nuclear Reservation, plutonium manufacture and the construction of the fated Washington Public Power Supply System (WPPSS) reactors into a regional shopping hub. Kennewick had a population of just over 14,000 in 1960; it is now home to almost 74,000 people. Steve Trotter, former electrician at Hanford, grew up in Kennewick and once used landmarks and familiar buildings to navigate his way through town.[31] He can no longer do that. Although family still resides in town, for him, Kennewick is no longer "home."

3.1.4 Exploring "Attachment to Place" and "Community Attachment"

Place identity and sense of place contribute to what scholars have termed "attachment to place" or "place attachment." Stokols and Shumaker define place attachment as a positive affective bond or association between individuals and their residential environment.[32] Others have broadened the definition to include any socio-physical environment of importance to a person, not just their residence.[33] Women displaced by the expansion of open pit coal mining in Jharkhand, India (formerly southern Bihar), mourned the loss of their fields, not their dwelling places.[34] They had spent their days planting seedlings, weeding, removing invasive shrubs, and cultivating rice, dhal, and other grains. At the new resettlement colony they had no space for farming or any type of agriculture. The women had nothing to do to occupy their day. Thus, place attachment for those women had been directed toward the spaces that gave meaning to their lives, not toward the buildings where they cooked and slept.

This example highlights the behavioral bonds that may complement the affective bonds of place attachment.[35] For the women of Jharkhand, attachment to the fields involved having a place to go each day that was outside the dwelling, having meaningful work to do, and being able to contribute to the well-being of the family. The women had learned cultivation techniques from their elders who had also worked that land and felt sad that they would not be able to pass that knowledge on to their children.

The example also demonstrates that place attachment involves personal commitment to a location. It is not a superficial connection, like that of passers-by or tourists. Indeed, Hay indicated that one feature of place attachment was being able to distinguish between residents and strangers, those who belong and those who do not, the insiders and the outsiders.[36] The intensity of the commitment or the bond depends on the length of time people have spent at a location, the unique features of the location, and the degree to which people share cultural or ethnic ties with others in that location.[37] It also depends on whether a person expects to stay in that location (what Hay and Guilliani both call “rootedness”) and if they feel a part of the larger community.[38]

Most scholars regard place attachment as something positive in a person’s life. Through place attachment people gain a feeling of belonging, a sense of purpose.[39] Place attachment provides a sense of security, stability, and day-to-day continuity that enables people to reach out, explore, and take chances in other parts of their lives.

They know that no matter what transpires elsewhere, they can always return to their place. Place attachments also can facilitate the establishment of friendship networks and formal or informal social relationships with others who live in or use the same location.[40] Those networks and relationships can then help support identity development and can bolster self-esteem.[41]

Brown and Perkins refer to negative experiences with and negative emotions attached to a location as failed attachments.[42] Failed attachments can occur if an individual holds rigidly to a set of beliefs or expectations as the world around them changes. They may result from the drudgery of unending routine or from feeling locked in a life situation from which there is no escape (women in abusive relationships, for example). In some cases, failed attachments will spur people to seek out locations better suited to them, ones to which they can find themselves positively connected. Unfortunately, that avenue is not open to everyone.

"Community attachment" differs from place attachment in the specific focus on the neighborhood(s) in which one lives or works. Community attachment finds its roots in interpersonal and social relationships, in group affiliations, in the roles an individual takes on in the community.[43] People attach themselves to what the neighborhood or community represents for them rather than to the physical settings themselves. Immigrants to the United States passing through Ellis Island often gravitated towards areas of New York City where they found other immigrants from their part of the world.[44] They moved to neighborhoods where people spoke the same language, enjoyed the same food, and shared their religious beliefs. Although many lived in overcrowded, squalid tenements with no running water and little ventilation, they found companionship and support in their neighborhoods. Fried found similar sentiments towards the slums of the West End of Boston in his studies of the 1960s. The West End was also populated by immigrants and working class Bostonians. They lived in tenements of which 63% lacked wash basins; almost 65% had extreme defects in windows, walls, or floors; 80% lacked fire escapes; and 60% showed signs of rat infestation.[45] Yet when forced by urban renewal to move, many West End residents expressed emotions similar to the sense of loss and grief that accompanies the death of a loved one.[46] The West End was their "world." In its narrow roads and sidewalks they made their friends and found the social safety net that could pull them through hard times. The crowded neighborhood alleyways became extensions of their homes. Their neighbors became their extended family. Fried learned through interviews that the more a person liked living in the West End and the greater their commitment to it before they were evicted, the greater was their grief afterward.[47] It was not the physical place, the bricks and mortar, for which they grieved; it was the social relationships and sense of community they missed.

As mentioned earlier for "insiders," both place attachment and community attachment can result in people acting on behalf of their place. In a study among residents of Svalbard, in the Norwegian High Arctic, those with a strong sense of place were more likely to express interest in finding solutions to environmental problems than those with a weak sense of place.[48] Residents of two municipalities along the coast of Norway took action to preserve their place when a downturn in the mining and fishing industries led to a reduction in available jobs, out-migration, and an aging population. Despite the economic downturn, those interviewed valued the quality of life available to them on the islands: "Here I have all the things that I need to live, the things that I feel in my backbone that I need to be able to live."[49] Groups in the two municipalities had gotten together to try to change the fate of their communities. They had begun by reinstating pride in the history and traditions of the area, organizing festival and outdoor activities to lure tourists. When the local public school closed, a group of individuals worked to open it as a private school within a year, keeping a key institution in their village.[50] Similarly, a study of lakeside property owners in Wisconsin found that those who most valued the "pristine" environment, the wildlife, and the "north woods" quality of the location were also those most willing to protect the lake against environmental change (including the increasing construction of single family homes and condominiums in the area).[51] The author concluded that those for whom the lake was an integral part of self-identity were more likely to defend it against outside forces.[52] In these and other examples, when place has meaning for people, they willingly work to keep from losing it.

3.2 Disruptions to Place Attachment

Eviction from one's home followed by the razing of the neighborhood structures is one example of how attachments to place can be disrupted. In Boston's West End, the physical space was destroyed and the community that grew up there scattered. Most of the farms, ranches, and the buildings of the towns of White Bluffs and Hanford fell before bull dozers and wrecking balls to make way for the Hanford Nuclear Reservation in 1943. However, disruptions can occur even without demolition of the physical space. During the Industrial Revolution of the 18^{th} and 19^{th} centuries (Chapter 2), millions of people left villages and small landholdings to seek employment in the burgeoning cities. They severed their attachments to time-honored farming and cottage industries to journey into the unknown territory of large factories and mass production.

Brown and Perkins explained disruption to place attachment as involving 1. A severe loss that causes routines, relationships, and expectations about one's place to fall apart; 2. An alteration in the physical objects in one's place, and the activities that involve them; or 3. A rupture in the continuity of the taken-for-granted frameworks of life.[53] Devine-Wright described disruption as occurring whenever physical changes negatively affect the symbolic meanings associated with place.[54] Thus, disruption can be the result of changes to physical aspects in the place itself, or of changes in the social or psychological environment of the place that affect how a person feels about it and reacts to it.

Brown and Perkins further distinguish voluntary and involuntary disruptions to place attachment.[55] Voluntary disruptions are planned and can be positive events (in the case of a job promotion and transfer, going to college, or relocation after retirement) or negative events (after a divorce). Because of their voluntary nature, people usually have time to prepare for these disruptions. The transition takes place gradually as people loosen their attachments to the old space and anticipate the benefits of the new. Once in the new location or new place, people may experience "home-sickness" as they think about the place they left behind—even though they will cultivate new friendships, establish new social networks, or engage in new types of activities, they can never replace what they left behind. Part of their self-identity has been lost. Many involuntary disruptions, on the other hand, are sudden, unpredictable, and usually, overwhelming. Earthquakes, hurricanes, flash floods, and other natural disasters can destroy everything that was central to peoples' self-identities. The physical space and the centers of meaning are gone, as are the social networks, the feelings of safety and security that place attachment can bring. Other involuntary disruptions may be known in advance, as is often the case with loss of dwellings and land to make way for development projects. Even though people have time to prepare, as in Boston's West End, grieving for losses can last for years.

Voluntary disruptions to place attachment can be almost as stressful as involuntary disruptions. In both cases, change overwhelms the stability and certainty that people had come to know and expect. Taylor, Gottfredson, and Brower posited that the lack of clarity of norms for behavior that would follow a disruption could be stress-inducing and might lead to conflict until new norms could be established and communicated.[56] In addition, people need to deal with their losses as they try to establish a meaningful place for themselves for the future. Some people cope by surrounding themselves with objects that remind them of the old place, by maintaining ties to the old place, or by seeking out activities or organizations that resemble those in which they used to participate. They try to recreate what they have lost. Other people use the disruption to establish entirely new types of attachments, to create new self-identities. Whether the disruption is voluntary or not, it will take time for people to establish bonds in a new location, to develop a new place attachment.

3.2.1 Disruptions to Place Attachment and Displacement

As explained in Chapter 2, displacement can occur when people are forcibly removed from their place, often involuntarily, to make way for the construction of large nuclear projects such as the Hanford Nuclear Reservation in the United States. That displacement results in a physical disconnection from the spaces people have come to know; more importantly, it also disrupts affective place attachments, it causes breaks in the emotional bonds people have formed, it tears apart formal and informal social networks, and it destroys the personal and community identities intertwined with that place. Displacement does not just involve a loss of pasture land or a house in the town square, it affects the cultural and social practices, the relationships between people and between people and the land, and it shapes memories of the past and dreams of the future. In this way, displacement and disruptions to place attachments are intimately connected.

Unfortunately, most view displacement only as a physical removal from one space and relocation to another. In 1998, the Representative of the Secretary General on Internally Displaced Persons of the United Nations did draft Guiding Principles to govern the treatment of people forced or obliged to flee or to leave their habitual residences but who did not cross national boundaries.[57] Although those Guiding Principles have been recognized as important for protecting the human rights of the displaced, they do not have legal standing. Thus, national laws usually guide displacements and relocations. In India, for example, the Right to Fair Compensation and Transparency Land Acquisition, Rehabilitation, and Resettlement Bill, 2013, stipulates that a Rehabilitation and Resettlement scheme be devised based on a survey of the lands and immovable property being acquired from each affected family, the livelihoods lost by landholders and the landless who depend on the lands being taken, and any common property resources that will be acquired.[58] The local Collector will assess the market value of the lands and property being acquired to be based on the average sale price for similar type of land situated in the nearest village, if possible, or at a minimum price per unit area as determined by the State Government if not.[59] The Collector then determines the amount to be paid to each family, based on the value of crops or livestock lost, foregone wages, and the like. Thus, the Collector determines the amount of compensation based only on the physical characteristics of the location and not any of the other attributes of their place, such as the meaning it may have in the history of their extended family.

Interestingly, because the Indian law, like many others, ties compensation to land and dwelling ownership, family members who are not on the deeds, or displaced fishermen and boat owners who ply a river about to be dammed, may not benefit from resettlement schemes. Their attachments to their place have been disrupted, they lose their place, and yet they receive nothing in return. As Ejaz Ahmed Khan poignantly recalled after his village was flooded by the construction of the Tarbela Dam on the Indus River in Pakistan,

> The authorities had deliberately not informed people, because they were not giving them their full rights . . . they released water without giving them proper compensation. How could people believe it would happen without compensation having been given? . . . [U]nless one receives the compensation, who would agree to leave a place? The water was coming up so fast that we could not lift [onto the trucks] all of the most necessary of our belongings . . . I was totally baffled, unable to understand what was happening. Our belongings, the house, the hujra [meeting place for men], and the banyan tree . . . that we used to climb and in which the bees used to make honey . . . I couldn't understand whether it was really water coming up or just a dream . . .[60]

3.3 A Process Model of Displacement

Approaching displacement from the perspective of place, sense of place, and place attachment adds new dimensions to its definition. No longer can displacement be identified only with the "involuntary physical removal of peoples from their historical or existing home areas as a result of actions by governments or other organizational actors," as suggested by Agarwal and Redford.[61] Displacement cannot pertain just to the families who have lost dwellings or land.[62] As Cernea indicated, displacement is socially caused *disruption* (emphasis added).[63] And, as has been demonstrated in this chapter, disruption can include alteration or loss of one's physical space; change in place-related activities; a failure of relationships or a shattering of expectations about one's place; or an upheaval in the taken-for-granted aspects of life in that place.[64] The definition of displacement must be broadened to include these cognitive and affective dimensions associated with place. While displacement can and often does involve the physical removal of people from their homes and lands, it may not. The Navajo were displaced by the expansion of the Snowbowl in the San Francisco Peaks; no homes were lost, but their spiritual center and centuries of tradition and culture were buried under feet of man-made snow. The establishment of conservation districts or wildlife preservation areas often strips local residents of access to natural resources—pasture land, watering holes for animals, wood for cooking fires. They have their homes but their lives and livelihoods are forever altered—they too have been displaced. The residents of Karel, Madban, Nate, Niveli, and Tulsunde, Maharashtra, India already worry about the six-reactor nuclear power plant the government has planned for their neighborhood. They express concern about the impact construction of the plant will have on their ability to raise and sell mangos and rice. They fear that changes in the local ecosystem will devastate the prized local mollusks and shrimp. They are concerned that radiation leaks from the power plant might make their fish unsalable. In their minds, their futures already were in jeopardy.[65] They too have been displaced.

Defining displacement narrowly in terms of physical movement of people and their belongings simplifies locating its beginning and end. In that view, it starts when people load the trucks with their clothes and household goods and it ends when they arrive at their new homes. If, however, displacement involves affective and cognitive dimensions and not just the physical relocation, it can be more difficult to identify when displacement begins and ends. People relocated to make way for the reservoirs behind hydroelectric dams in China continued to feel displaced even after being resettled by the government. They did not receive adequate compensation to buy food or clothes or to build homes in the new areas.[66] Overcrowding in the resettlement locations led to overharvesting of wood and destruction of grasslands. Many moved back to slopes of the reservoirs, near their former homelands.[67] The fishermen of the Jaitapur region have not lost their homes, their boats, or their livelihoods, but the awareness of the planned nuclear plant and its consequences has affected their sense of security and their confidence about what the future will hold. In either case, marking the beginning or end of displacement is not straightforward.

Looking at displacement only as the physical movement of people and their belongings also fails to take into account the nature of most development and technology projects. Such projects take time to plan, execute, operate, and, in some cases, to shut down. Different groups may be experience disruption of their place attachment or may be displaced, at different points in time. As just described, the fishermen and farmers at Jaitapur felt displaced as the Nuclear Power Corporation of India (NPCIL) and the Indian government representative began to disseminate plans for the nuclear power facility in their district. Operation of a nuclear power plant (or hydroelectric facility) takes special skills, skills not usually possessed by the people in the rural areas where they get built. Thus, during the operation of the plants, local residents may feel displaced by outsiders that come to operate or support the operation of the facilities. Even after a facility closes, displacement continues. Barbed wire fences still surround the exclusion zone of the Chernobyl Nuclear Power Station, warning visitors of the radiation danger that lies within. About 1200 people defied the government and returned to their ancestral villages after being hastily evacuated in 1986. Although the 200 or so babushkas scattered throughout the zone continue to face harsh conditions and must fend for themselves, they contend that those who left are worse off—they die of sadness.[68]

Allowing for displacement at various stages during the life of a nuclear project requires a new conceptualization of displacement. The Process Model of Displacement, depicted in Figure 3.1 below, represents one such conceptualization. The boxes in the model emphasize four different points during the life of the project at which displacement can and does occur: during the planning phase (which includes the acquisition of land), during construction, during operations, and after the facility has been shuttered (here labeled "legacy").

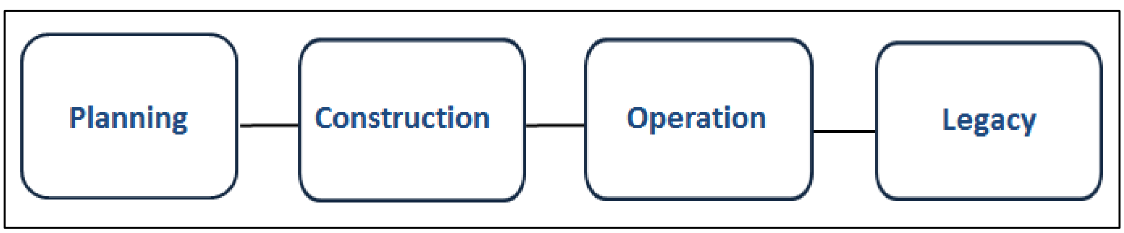

Figure 3.1 The Process Model of Displacement

According to this model, the process of displacement begins as soon as people learn of the nuclear technology project—from the media, from government representatives, from family and friends. Displacement continues as land gets acquired for the project and as different groups of workers get uprooted from their various whereabouts to journey to a specific location to design and build assorted aspects of the project. Operations bring in a different set of experts to run and maintain a nuclear facility. Accidents like those at Chernobyl or Fukushima Dai-ichi can result in abrupt evacuations of a site and creation of exclusion zones. Another legacy of nuclear operations may be the decommissioning of shuttered facilities and the entombment of years of accumulated radioactive waste. That creates another type of exclusion zone, displacing people for thousands and thousands of years.

It should be noted that displacement need not occur in the orderly progression of stages as depicted in Figure 3.1. At the Hanford Nuclear site, after the last reactor shut down in 1987 attention turned to cleaning up what remained of decades of work producing plutonium. Construction of a new vitrification facility began in 2000--a facility that would trap radioactive waste in glass bricks or logs, preventing that waste from migrating into the environment. Thus, although the Hanford site has reached the legacy phase of the Process Model, a new cadre of construction workers has arrived in eastern Washington. Those construction workers too have been displaced from other jobs to join the legions who have worked at Hanford. As at Hanford, loops backward and forward can connect the lifecycle stages in the model, depending on the particular case or situation being examined.

This dissertation explores the nuclear technology projects at Hanford, Chernobyl, and Jaitapur to examine both the Socio-Political Ecology framework developed in Chapter 2 and the Process Model of Displacement described here. Chapter 4 explains in more detail the three case studies and the methods used to investigate them.

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Chapter 4

RESEARCH DESIGN AND METHODOLOGY

Chapter 2 introduced a Socio-Political Ecology framework for understanding nuclear technology choices. It argued that Political Ecology did capture the political climate and economics, the technological and environmental dimensions of decision making, but it failed to capture the impact those decisions had on people. In particular, large scale nuclear energy projects displace people from their homes and their land. Incorporating that social dimension into the model provides a more complete picture of the benefits and costs of nuclear projects. Chapter 3 argued for a multi-stage Process Model of Displacement associated with nuclear power, a model that encompasses its physical, psychological, and emotional aspects. Unlike much of the displacement literature, that model does not assume that displacement is a single, well-circumscribed event or the inevitable consequence of modernity or development. Instead, as part of an effort to bring ties to the Place/Sense of Place and Displacement to the forefront of decision-making about nuclear technology, it asserts that displacement can occur throughout the life cycle of such projects. It views displacement as an ongoing psychological and physical process that starts as soon as planning begins and can continue even after a facility ceases operations. A combination of the Socio-Political Ecology framework with the Process Model of Displacement yields a new approach to understanding the displacement associated with nuclear technology projects, depicted in Figure 4.1 below.

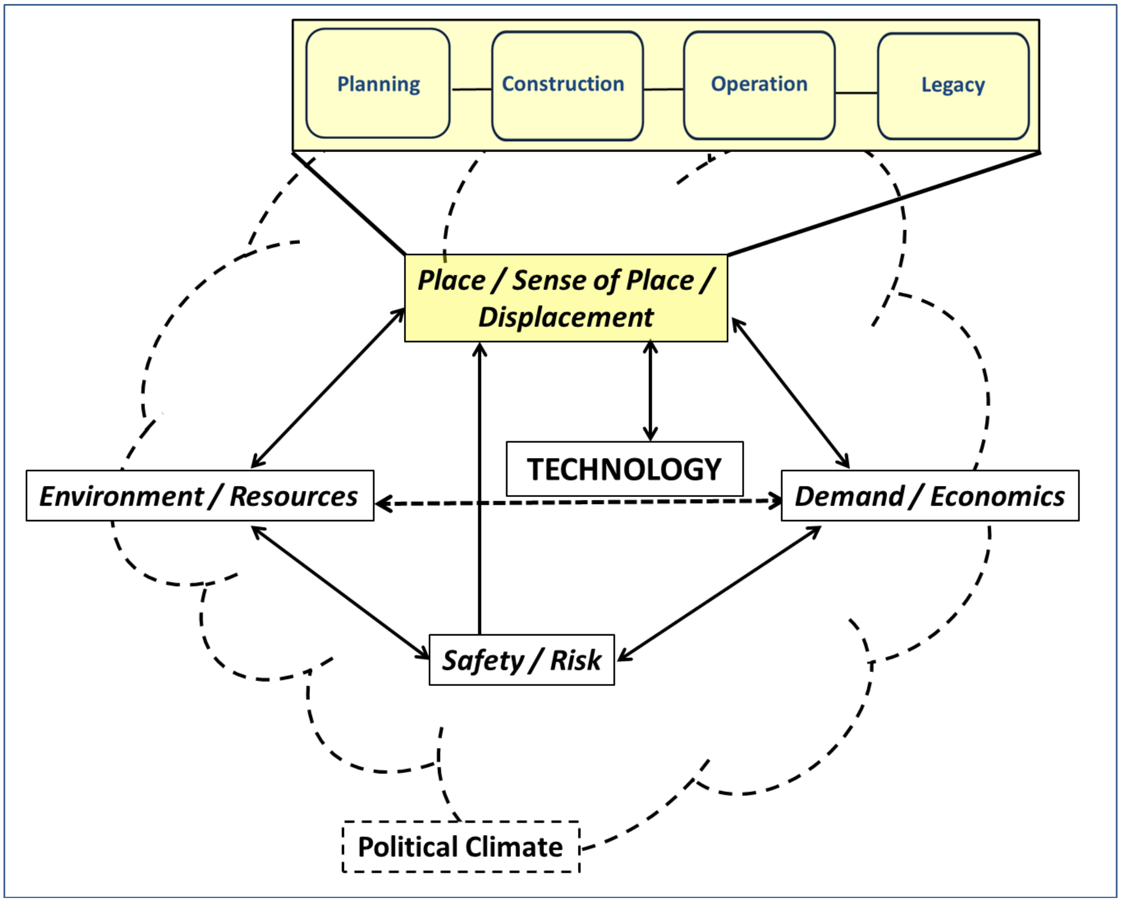

Figure 4.1 A Combined Model for Understanding Displacement

This research uses case studies to illustrate the value of the Process Model of Displacement and the combined model illustrated in Figure 4.1. As is explained in more detail in Appendix B, a case study allows for the consideration of the interplay of variables in a real-world situation, in order to develop a comprehensive understanding of the subject of the case study. In particular, this dissertation research spotlights the displacement that can result from the application of nuclear technology (as touched upon in Chapter 3, displacement due to dam construction, the establishment of environmental reserves/preserves, or due to economic growth in the developing world have been covered in the literature). Furthermore, because of the need to examine displacement at different stages of a project, it looks at the displacement associated with nuclear technology at various points in time. It probes what occurred in the early 1940s as the farms of eastern Washington and the traditional fishing grounds of the local Native American Tribes were appropriated by the U.S. government to build a plutonium production facility. It examines the transformation of a rural area of the Soviet Union into an "atomohradom" (atomic city) of more than 47,000 people and a nuclear power complex containing six RBMK 1000 MWe reactors in the 1970s and 1980s.[1] This research looks at the physical and psychological impacts of the Chernobyl accident as well as the psychological stress caused by revelation that people living near the Hanford Nuclear Reservation had been exposed to high levels of radiation during periodic gaseous releases iodine 131 from that facility.[2] It examines the continuing displacement caused by the exclusion zones set up around Hanford and Chernobyl. The research also investigates the early indications of displacement in Jaitapur, Maharashtra, India, near the site of the proposed nuclear reactor electrical generation facility. Finally, unlike most of the work on development-induced displacement, with an emphasis on examples from developing nations, this dissertation draws on material from a developed country, the United States, as well as from Ukraine (then part of the Soviet Union), and India. When looked at as a whole, the data from these three case studies represent displacement associated with the various stages in the life cycle of a nuclear power facility, from the early design and siting stage through the attempts to determine what to do with highly radioactive waste and contaminated lands. The case studies incorporate information about environmental issues considered at each site, the political, economic, and/or electrical demand rationale for the construction of the nuclear power facilities, and the impact of all of those on place, sense of place, and displacement.

Appendix B provides background information about case study research and the use of case studies. This chapter concentrates on explaining the choice of the three cases: 1. The construction, operation, and decommissioning of the Hanford Nuclear Reservation (hereafter referred to as "Hanford"); 2. The operation, 1986 catastrophe, and ongoing "exclusion" at the Chernobyl Nuclear Power Plant ("Chernobyl"); and 3. The pending construction of the Jaitapur Nuclear Power facility in Maharashtra, India ("Jaitapur"). It then provides an overview of the approach taken to discover examples of displacement and reveal how displacement has occurred at the three sites. The chapter also discloses some of the sources of data tapped for this research. Underlying the information presented here is the belief that the archival and interview data can combine to present a rich picture of the physical and psychological displacement that has occurred and/or is occurring at each site.

4.1 The Choice of Case Studies

This research aims to illustrate the Socio-Political Ecology framework and underscore the importance of studying displacement using a multi-phased approach such as Process Model presented earlier (See Figure 3.1). It also addresses the question: What can be learned from Hanford, Chernobyl, and Jaitapur that might be useful in understanding nuclear technology-induced displacement and for informing future decisions regarding the use of nuclear technologies that involve "dis-placing and re-placing" populations?[3] The question then arises, "Why choose Hanford, Chernobyl, and Jaitapur and not three other sites where nuclear technology has been employed?" As clarified further below, the three sites possess characteristics of value for this research. Additionally, I chose these particular sites as case studies because of my previous experiences with them and my concerns for them and their inhabitants.

Tuan and Relph explained that undifferentiated space becomes "place" through individual experiences and knowledge that give a space value. Space becomes place through individual interactions with it and knowledge of it. Place then evolves through personal connections with the space, the meanings ascribed to it, and the memories of events associated with it. According to Relph, concern for place results from a mixture of past and current experiences with it, expectations about its future, and the development of a sense of responsibility for the place and what it means in the lives of the people occupying that place.[4] In that vein, my interest in and concern for Hanford, Chernobyl, and Jaitapur arise out of visits I have made there to witness the impact of nuclear technology, my discussions with people about those impacts, and the extensive reading I have done over the years about nuclear power there and around the world.

I visited Chernobyl in 2007, long before I ever conceived of this research. I gazed at the stricken reactor, walked through the streets of Pripyat, and meandered down abandoned lanes of empty towns. Our study group had the chance to speak with researchers about the long-lasting effects of radiation on the region's crops, animals, and children. We heard from activists and government officials about their understandings of the seriousness of the accident at Reactor number 4. Still, ". . . I will always remember Chernobyl for the sense of life interrupted, the uneasy silence it brought to that corner of Ukraine."[5] Although my experiences of Hanford are not as extensive, I have toured its cavernous B Reactor, the first large scale nuclear reactor built anywhere on earth and one that produced plutonium for atomic weapons. I have driven across the site, past the barbed wire fences, along rutted dirt roads, near buildings that have been left to the ravages of time. For miles in any direction the area seems flat, lifeless, and deserted. However, that peaceful surface obscures the toxic legacy of plutonium production at Hanford: the leaking of radioactive waste and toxic chemicals from underground storage tanks has been in the news in the Pacific Northwest for decades.[6] I first heard about Jaitapur more recently, during a 2013 study visit to the Mumbai, India, area. Fishermen and activists from Greenpeace India gave us a glimpse of the issues associated with nuclear power plant construction in Maharashtra. I journeyed to the Jaitapur region to speak with more of the project affected people in March, 2015. Unlike the United States, where new nuclear reactors are being built on land at existing nuclear power plants and thus face little opposition, the Indian government has plans for nuclear reactors at new sites along the coasts and across the country.[7] Many local people have joined protest marches and children have stayed away from classes in which government officials required teachers to extol the virtues of nuclear power.[8] Thus, my previous experiences with Hanford, Chernobyl, and Jaitapur, and my ability to connect to them as places, not just dots on a map, led me to choose those to sites for this dissertation research.

I could have explored the displacements associated with Windscale, UK, the site of a reactor fire in 1957 that released radioactive iodine into the atmosphere, or the more recent March 2011 meltdown and explosions after an earthquake and tsunami at the Fukushima Dai-ichi facility in Japan. However, I have not yet visited those sites. I could have looked into displacements due to the construction of units 2 and 3 at the Virgil C. Summer Nuclear Generating Station in South Carolina or units 3 at Olkiluoto in Finland. But there is one existing reactor at the Summer site and two at the Olkiluoto site, and for this displacement research I sought to find an example of new nuclear construction at a site not already home to a nuclear reactor. Furthermore, I wanted three cases that occurred at very different points in the history of nuclear power, allowing for an assessment of adjustments in attitudes towards or policies regarding displacement over time. What, if anything, has changed over those 70 plus years since ground was broken for the first reactor at Hanford? In the end, Hanford, Chernobyl, and Jaitapur truly fit my case selection criteria.

Table 4.1 below provides an overview of the three cases chosen for this research and the potential types of displacement associated with each.

Table 4.1 Overview of the Case Studies

Site	**Time Span**	**Location**	**Displacement Phase(s)**	**Brief Description of Possible Displacements**
Hanford	1940s to present	USA	As a part of planning, construction and operations; Due to operations; The legacy of those operations	Involuntary physical displacement of farmers, Native Americans to build the facilities; Physical relocation of employees and their families; Psychological displacement of the "Downwinders"; Ongoing physical displacement from the hazardous site
Chernobyl	1970s to present	Ukraine (then part of the USSR)	As a part of construction and operations; Due to a catastrophic event; The legacy of that event	Physical displacement of original landholders; Physical relocation of employees and their families; Forced dislocation due to the 1986 accident; Physical and psychological displacement of "Chernobylites"; Ongoing displacement from the Exclusion Zone
Jaitapur	2010s	India	Planning	Involuntary psychological displacement of farmers, fishermen, villagers before construction begins; Physical displacement of landholders at the site

The most obvious difference between the three cases is the time span covered by each. For Hanford, the time clock started in the 1940s and continues to this day. For Chernobyl, it began about 1970 and still continues. For Jaitapur, the clock started much more recently—the Jaitapur site was approved “in principal” in October 2005.[9]

The countries represented in this work also span the globe: the United States, Ukraine (the former USSR), and India. As mentioned earlier, this research on displacement does not focus only on events occurring in the developing world.

This dissertation proposes displacement as a process rather than a single event, and thus begins by looking at the psychological displacements that can occur prior to the actual construction itself, when projects have been announced, when land acquisition and eviction begins. For the Hanford Nuclear Reservation, pre-construction phases of the project occurred in 1942, with the choice of a site along the Columbia River for the nuclear weapons complex; for Chernobyl, in the 1970s; and Jaitapur currently falls into that pre-construction phase. At the Hanford site, local farmers and townspeople received 15 – 90 day notices to vacate their homes, businesses, and lands for reasons that remained cloaked in the mystery of the war effort and the Manhattan Project. Even though the facilities at Jaitapur have yet to be built, people have been experiencing that psychological impact of the proposed construction for some time. The Indian government, in conjunction with the Nuclear Power Corporation of India (NPCIL) and French nuclear power companies, has worked since the 1980s to design and build a nuclear facility at the Jaitapur site. In October 2005, approval was given for the construction of two 1000 MWe reactors there.[10] In 2009, NPCIL and France's Areva signed a memorandum of understanding to build two European Pressurized Water Reactor (EPR) units and to provide fuel and other services for a total of six EPR units at Jaitapur. In 2011, NPCIL announced the compensation package for land it would acquire for the facility.[11]

At Hanford, physical displacement and re-placement followed the psychological as people moved to the site to help build the new facilities and as employees moved to the newly constructed towns of Richland, Kennewick, and Pasco, Washington. Since all the former inhabitants of the area had been evicted, the towns had no history, no past, only a future yet to be established. In a similar manner, the idyllic town of Pripyat, Ukraine emerged from the Russian marshland to serve the workers of the nearby Chernobyl nuclear power facility. Founded in 1970, the town swelled to a population of almost 50,000 before being forcibly evacuated and abandoned in 1986.

Displacement also continued in various forms during other stages of the nuclear projects. In the case of Chernobyl, the catastrophic explosion and fire of 1986 caused a one-time physical displacement of hundreds of thousands of residents of Ukraine, Belarus, and Russia, as well as the displacement and re-placement of hundreds of thousands of "liquidators" who toiled to cap the reactor and clean up the accident site. Both Chernobyl and Hanford also exhibit an ongoing, legacy displacement. For Chernobyl, this resulted from the accident and the contamination of wide swaths of the surrounding area with radioactive iodine, strontium, and cesium.[12] A chain link fence surrounds approximately 2,600 km^2 (1,000 mi^2) of land, including the plant and nearby areas most contaminated by radiation. Even 30 years later, dosimeters register maximum radiation at hot spots inside the fence. Although roughly 1,200 of the elderly moved back to the zone in the years following their evacuation, and although both Belarus and Ukraine have indicated their interest in establishing agriculture in the exclusion zone, that zone remains off-limits to all but the tourists who pay to spend a day there and a few research scientists.[13] At the Hanford site, workers originally disposed of wastes from the manufacture of plutonium in single-walled, underground "tanks." Over the decades, those tanks, some of which date back to 1943, began to leak radioactive materials into the surrounding soils. Even leakage from newer, double-walled tanks has now been detected.[14] As a result, like Chernobyl, parts of the Hanford site remains off-limits to the general public.

Figure 4.2 below depicts the different phases of a nuclear project during which displacement can occur, as just described. It differs slightly from the previous version of the Process Model of Displacement in that it highlights the two different paths taken to reach the legacy state: at Hanford, operations ceased after the need for plutonium fell at the end of the Cold War; at Chernobyl, operation of Unit 4 came to an end as the result of the catastrophic accident in 1986. (Note: Due to the need for electricity, the completed units at the Chernobyl plant continued to operate after the catastrophe: Unit 2 shut down after a fire in 1991, Unit 1 closed in 1997, and Unit 3 finally closed in 2000. See Chapter 6.) Figure 4.2 also lists the primary (and secondary) cases used to provide information about displacement during each of the phases. The figure reinforces the idea that while Hanford, Chernobyl, and Jaitapur are all case studies related to the use of nuclear technology, there are similarities and important differences among them which, when taken together, provide key insights into the relationship between the choice to employ nuclear technology and various aspects of displacement.

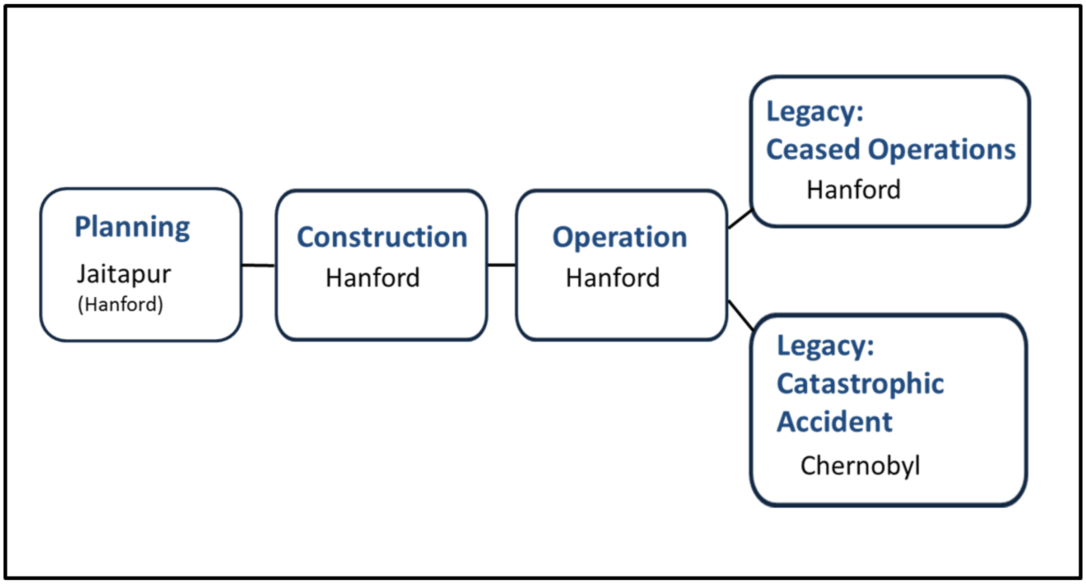

Figure 4.2 Expanded Process Model of Displacement and Associated Case Studies

4.2 Knowing Displacement When We "See" It

The beginning and ending of displacement can be relatively easily identified when the concept has been defined as the physical removal of people and their belongings from their historical or existing home areas. However, when conceived of as a process and not a discrete event, when displacement involves both psychological and physical dimensions, the task becomes more difficult. There is no specific start date or completion time. Furthermore, in a process model, displacement encompasses a wide range of emotions and occurrences that can be described using a wide range of words. The published work describes displacement using phrases such as the movement of people, populations being forced out, eviction, resettlement, and relocation. Bennett and McDowell speak of "the rupture from ancestral lands" and the "sudden and uncompromising removal from what is familiar."[15] Parr describes the estrangement and disorientation experienced by villagers displaced by the erection of a hydroelectric dam in British Columbia.[16] From the literature on place and place identity come ideas of attachment, rootedness, and belonging.[17] People's concept of their relationship with place helps define their sense of self and make sense of the world around them.[18] Since a person's relationships with place helps define their sense of self and make sense of the world around them, with dis-placement come feelings of confusion, detachment, placelessness, and being an outsider. In this sense, displacement brings a rupture with the past, a sense of loss, and often a complete upheaval in life. Yet even as the literature on displacement largely expounds on the negative aspects of displacement, some of the displaced find new educational or opportunities, freedom from oppression or harassment, a renewed sense of safety, increased social mobility, or an increased standard of living.[19] All of these conceptions and more could be uncovered in this research into understanding the displacement associated with nuclear technology.

Figure 4.3 below displays a word cloud or word map of displacement and related concepts gleaned from the literature, as well as synonyms of those concepts. The words in the cloud, and many others not included there, indicate some level of physical or psychological displacement. These words provided the foundation for this investigation of the displacement associated with nuclear power projects. Finding these types of words in print would alert me that the archival sources I was examining were indeed documenting some type of displacement. Hearing these words let me know my interviewees had experienced some sort of psychological or physical displacement. These words let me know I was "seeing" displacement.

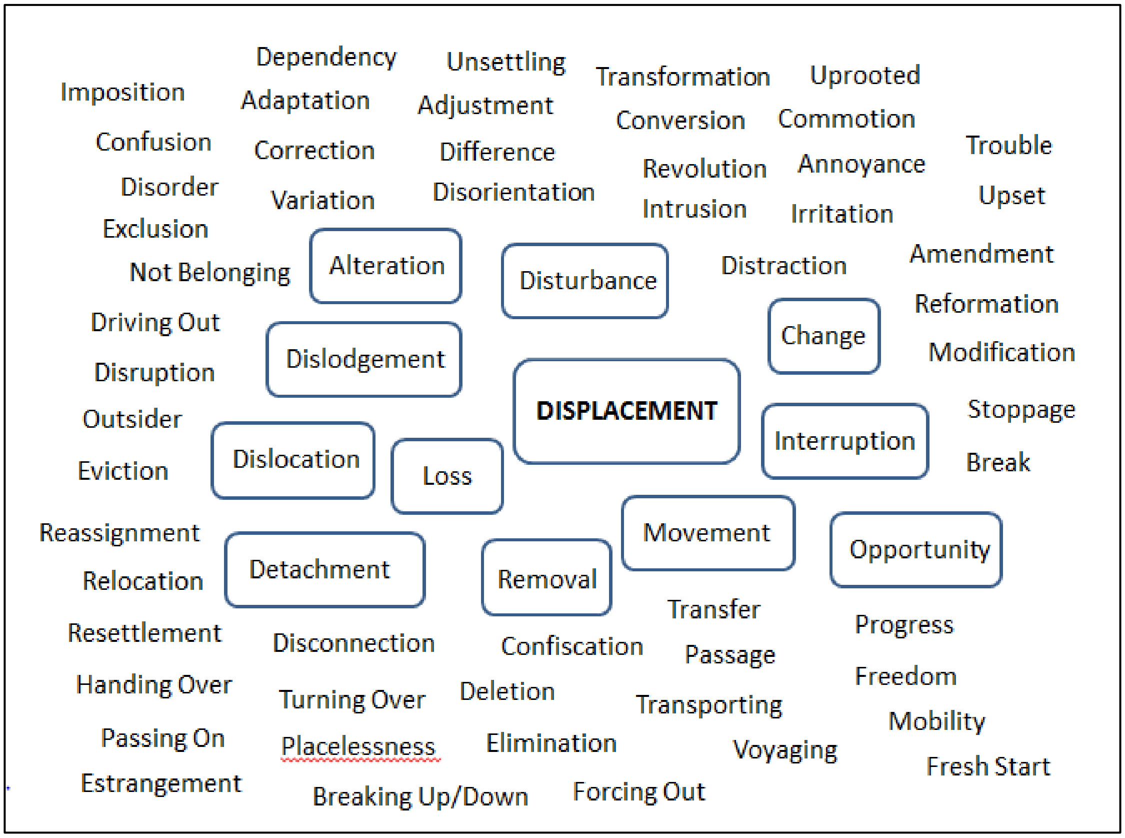

Figure 4.3 Displacement and Related Concepts

The questions developed to guide this research combined words like those displayed in the word cloud with the concepts outlined in the Socio-Political Ecological framework and Process Model of Displacement. Those questions, concepts, and the framework, in turn, guided the examination of archival material related to Hanford, Chernobyl, and Jaitapur for evidence of displacement.[20] For example, during May of 2014, I combed the archives of the DuPont Company of Wilmington, DE, the original contractor for the Hanford facility, to find information related to *moving* engineers and scientists and other company employees to Washington State to support the construction and/or operation of the new facility.

Similarly, Indian media stories were examined to find evidence of the *disorder, agitation, and unrest* that has been associated with the Jaitapur project over the last decade. Note however that no attempt has been made to quantify displacement in any sources—this dissertation contains no statistics on the frequency of mention of displacement or related concepts, and no counts of times those concepts appeared in the archives.

4.3 The Data

A list of questions developed to guide the gathering of data can be found in Appendix C. While not all are discussed in this dissertation, they guided the "soaking and poking" phase of the research[21], the immersion into the three case studies, according to the Socio-Political Ecology and displacement ideas laid out in Chapters 2 and 3. The sections that follow describe specific aspects of the archival and interview data collection.

4.3.1 Archival Data and Secondary Literature

The Hagley Museum and Library in Wilmington, DE housed boxes of archival material related to the E. I. DuPont de Nemours & Co.'s involvement in the Hanford project. That now de-classified material included file memos and records relating to the acquisition of the land in Washington State and the cost of relocating employees and their families from Delaware and Chicago, photos of the newly constructed dormitories and houses in Washington, data related to the types of houses and services available at the new sites, and information about worker retention issues. The archives also included a variety of newspaper clippings relating to Hanford and the bombing of Japan. Stories from the *Seattle Times*, *Seattle Post Intelligencer*, and Spokane's

Spokesman-Review, and documents from the Environmental Protection Agency provide additional insight into the more recent history of the site.

Books dealing with the history of Hanford that served as secondary sources for this dissertation included *Tales of Richland, White Bluffs, & Hanford 1805 – 1943, Before the Atomic Reserve* by Martha Berry Parker (1979); Paul Loeb's *Nuclear Culture: Living and Working in the World's Largest Atomic Complex* (1986); *Atomic Farmgirl: Growing Up Right in the Wrong Place* (2003) by Teri Hein; *Orchards of Eden: White Bluffs on the Columbia, 1907 – 1943,* by Nancy Mendenhall (2006); *The Manhattan Project: The Birth of the Atomic Bomb in the Words of its Creators, Eyewitnesses, and Historians*, edited by Cynthia C. Kelly; *Atomic Frontier Days: Hanford and the American West* by Findlay and Hevly (2011); and Kate Brown's *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters* (2013).

Archival material for Jaitapur consisted primarily of government documents related to the project, including the National Environmental Policy (2006), coastal zone clearance for construction at the site, the Environmental Impact Assessment (EIA) for two 1000 MWe light water reactor category Nuclear Power Plant (NPP) units at Jaitapur, information about the compensation and rehabilitation packages as worked out by the Nuclear Power Corporation of India Limited (NPCIL) for the land needed for the Jaitapur facility, and the Tata Institute of Social Sciences "People's Report: Social Impact Assessment of Jaitapur Madban Nuclear Power Plant." Secondary literature included a dissertation written by Manu Mathai entitled *Beyond Prometheus and Bakasure: Elements of an Alternative to Nuclear Power in India's*

Response to the Energy-Environment Crisis (2010), and Ramana and Reddy's *Prisoners of the Nuclear Dream* (2003).

I have relied on books to understand the Soviet nuclear complex, what led up to the catastrophe at Chernobyl, and what ensued. Among those books: David Marples ' *Chernobyl and Nuclear Power in the USSR* (1986); Marples and Snell's *The Social Impact of the Chernobyl Disaster* (1988); Peter Gould's *Fire in the Rain: The Democratic Consequences of Chernobyl* (1990); *The Legacy of Chernobyl* by Zhores Medvedev (1992) (English Translation); Cheney's *Journey to Chernobyl: Encounters in a Radioactive Zone* (1995); Alexievich's *Voices from Chernobyl: The Oral History of a Nuclear Disaster* (1997) (English translation); Josephson's *Red Atom: Russia's Nuclear Power Program from Stalin to Today* (2000); *Wormwood Forest: A Natural History of Chernobyl* by Mary Mycio (2005); and the more recent *Producing Power: The Pre-Chernobyl History of the Soviet Nuclear Industry* by Sonja D. Schmid (2015). I also have my own copious notes from meetings with physical and agricultural scientists, activists, governmental and non-governmental representatives during a study trip to Ukraine and Chernobyl in 2007.

As would be expected, the archival material for the Hanford project was written in English. Most of the material for Jaitapur is also written in English--the Indian constitution specifies that English can be used for official purposes, and most documents and articles pertaining to this project followed that tradition. On the other hand, I have had to rely on translations for most of the material related to Chernobyl. Because most of those materials were written for other purposes, with other objectives, I do not feel the source materials or their translations were biased either for or against discussing displacement associated with the nuclear facility there. In addition, I have examined those materials for facts, for data, rather than opinions or impressions of the events, reducing the possible bias. Still, I cannot know for sure whether or not the authors or their translators added bias through the choice facts they did present or their choice of words, or in the selection of articles or books made available in English. For example, if journalists felt the American public would be more receptive to material critiquing the Soviet government handling of the events at Chernobyl, they might have sought out publishers in the West.

4.3.2 Interviews and Oral Histories

To supplement my archival research on Hanford, I gained access to oral histories gathered as part of the Hanford History Project of Washington State University Tri-Cities and to the Atomic Heritage Foundation's "Voices of the Manhattan Project." The latter included of the transcripts of interviews gathered by former newspaper reporter Stephen L. Sanger—interviews that formed the bases of his books *Working on the Bomb: An Oral History of WWII Hanford* and *Hanford and the Bomb: An Oral History of World War II*.[22] It also includes oral histories gathered by Stephane Groueff in in 1965 and those collected by the Atomic Heritage Foundation in the 2000s.[23] The Hanford and "Voices of the Manhattan Project" oral histories are part of the Manhattan Project National Historical Park, overseen by the U.S. National Park Service. Table 4.2 lists the range of people whose oral histories were reviewed as part of this research.

Table 4.2 Hanford Oral Histories

Hanford Engineer Works Oral Histories
Colonel Frank Matthias, Officer in Charge
Member of the U.S. Army
Site Supervisor
Chemist
Health Physicist
Radiation Monitor/Radiation Biologist
Environmental Monitor
Engineer
Metallurgist
Construction Worker
Security/Police Officer
Mess Hall Worker
Secretary/Typist
Catholic Priest
Wife/Child of Hanford Worker
People from the area who lost land
Native Americans

A meeting in January 2013 with some of the people affected by the proposed Jaitapur Nuclear Power Plant and background reading on the project led to the formulation of a preliminary list of broad categories of people that would be included in interviews or groups discussions. That list was further refined with the help of a subject matter experts in India. A member of the local police force originally had agreed to be interviewed as part of the project, but was called away by the time I reached the area. Table 4.3 below lists those who eventually participated in interviews and focus groups for the research trip in March 2015. See Appendix D for a more detailed schedule of the visits.

Table 4.3 Jaitapur Interviewees

People Still in the Affected area
Impact on Livelihood
Fishermen--Village Nate
Fishermen--Village Tulsunde
Other fishermen
Others in Village Tulsunde in business activities
Others in Village Nate in business activities
Land Appropriation
Farmers/Villagers--Madban
Farmers/Villagers--Mithgavane
Families who will become landless
Families disputing compensation
Lawyers representing families disputing compensation
Economic Impact
Local government officials
People Outside the Affected Area
Activists
Researchers at the Tata Institute

Mr. Pradeep Indulkar, formerly of Bhabha Atomic Research Centre (BARC) and award winning documentary filmmaker, made the arrangements at the local level. Due to the potentially sensitive nature of the discussions, permissions were secured in advance from village officials (for example, the Gram Sarpanch, the Gram Panchayat, and the district collector). In addition, villagers involved in the interviews/discussions understood in advance the nature of the discussions and agreed orally to participate. Initially, it was hoped participants would fill out questionnaires related to their experiences with the planned nuclear power plant. (See Appendix E for a sample of the questionnaire questions.) However, because of concerns about who might gain access to those written materials and the possibility that they might be used against the villagers, I chose to ask questions orally and take notes, focusing on understanding the impact of the proposed facility. Group discussions were taped. Although many people did speak English, villagers often preferred to speak in their local dialect of Mahrati. Mr. Indulkar served as translator. Because Mr. Indulkar hails from the Jaitapur area, speaks both the local dialect of Mahrati and English fluently, and understood the focus of my research in advance, I trust the soundness of his translations of both my words and the responses to my questions. Still, because the people with whom we met knew of Mr. Indulkar's anti-nuclear activism, it is possible there was some bias in how they responded to my questions. Notes were taken during one-on-one sessions and groups talks were taped, unless participants objected. Photographs also documented most of the participants in the interviews. All of the letters and forms were translated into the local language; and two sample English versions can be found in Appendix F. Most discussions with people affected by the Jaitapur Nuclear Power Project occurred during a March 2015 trip to that area.

Together, the interviews and archival data provide the data for this dissertation. The chapters that follow review that data as it pertains to the Socio-Political Ecology Framework and the Process Model of Displacement.

ENDNOTES

[1] “The Anniversary of that Failed,” February 4, 2015, http://chnpp.gov.ua/uk/news/1802-yuvilej-shcho-ne-vidbuvsya.

[2] “Hanford Thyroid Disease Study (HTDS),” Centers for Disease Control and Prevention (CDC), August 19, 2010, http://www.cdc.gov/nceh/radiation/hanford/htdsweb/guide/history.htm.

[3] Note that due to its evolving nature of qualitative research, no explicit null and alternative hypotheses need to be formulated or examined. Instead, a research question is posed, albeit one that may change over the course of the research. (Frances Ryan, Michael Coughlan, Patricia Cronin, “Step-by-step Guide to Critiquing Research. Part 2: Qualitative Research,” *British Journal of Nursing* 16, no. 12 (2007): 738 – 744.).

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[5] Kathleen Saul, “Chernobyl Memories,” April 14, 2009.

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[12] See Zhores Medvedev, *The Legacy of Chernobyl* (New York, NY: W. W. Norton and Company, 1992).

[13] Holly Morris, “After Chernobyl They Refused to Leave,” Special to CNN, November 7, 2013, http://www.cnn.com/2013/11/07/opinion/morris-ted-chernobyl/; “Ukraine Wants Chernobyl Exclusion Zone to Bear Fruit,” January 6, 2011, http://rt.com/news/features/ukraine-chernobyl-exclusion-zone/; Steven Lee Myers, “Belarus Resumes Farming in Chernobyl Radiation Zone,” *The New York Times*, October 22, 2005, http://www.nytimes.com/2005/10/22/international/europe/22belarus.html?pagewanted=all&_r=0.

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[16] Joy Parr, *Sensing Changes: Technologies, Environments, and the Everyday, 1953 – 2003* (Seattle, WA: University of Washington Press, 2010), 124.

[17] *Human Behavior and Environments: Advances in Theory and Research. Vol. 12: Place Attachment*. ed. Irwin Altman and Setha M. Low (New York, NY: Plenum Press, 1992); Lynne C. Manzo, “Beyond House and Haven: Toward a Revisioning of Emotional Relationships with Places,” *Journal of Environmental Psychology*, 23 (2003): 47 – 61; Relph, 37 – 38; Yi-Fu Tuan, “Rootedness Versus Sense of Place,” *Landscape* 24 (1980): 3 – 8.

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[20] Thomas, R. Murray, *Blending Qualitative and Quantitative Research Methods in Theses and Dissertations* (Thousand Oaks, CA: Corwin Press, Inc., 2003), 57.

[21] Alexander George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge, MA: MIT Press, 2005), 89.

[22] S. L. Sanger and Craig Wollner, *Working on the Bomb: An Oral History of WWII Hanford* (Portland, OR: Continuing Education Press, 1995); S. L. Sanger, *Hanford and the Bomb: An Oral History of World War II* (Seattle, WA: Living History Press, 1990).

[23] See "Voices of the Manhattan Project," http://manhattanprojectvoices.org/.

Chapter 5

CONTEXTUALIZING HANFORD

> Yet the past is ever with us and all that we are and that we have comes from the past. We are its products and we live immersed in it. Not to understand it and feel it as some-thing living within us is not to understand the present. To combine it with the present and extend it to the future, to break from it where it cannot be so united, to make of all this the pulsating and vibrating material for thought and action—that is life.
>
> Jawaharlal Nehru, *The Discovery of India*[1]

As Indian Prime Minister Nehru so eloquently stated, nothing occurs in a vacuum. Everything has a past that defines it, shapes it, delineates it, distinguishes it, colors it, gives it meaning and direction. Therefore, before investigating the displacement associated with the nuclear technology projects at Hanford, Chernobyl, and Jaitapur, it is vital to understand the context in which those projects have occurred. This chapter and the two that follow delve into that context using the general Socio-Political Ecology framework introduced in Chapter 2 of this dissertation. Figure 5.1 below presents the basic framework for the three case studies. As might be expected, some factors have greater weight for some of the projects than for others, as the times, scientific understanding, and local needs changed. Once the context for each case study has been established, the discussion turns to the displacement processes associated with each of the three cases (Chapter 8).

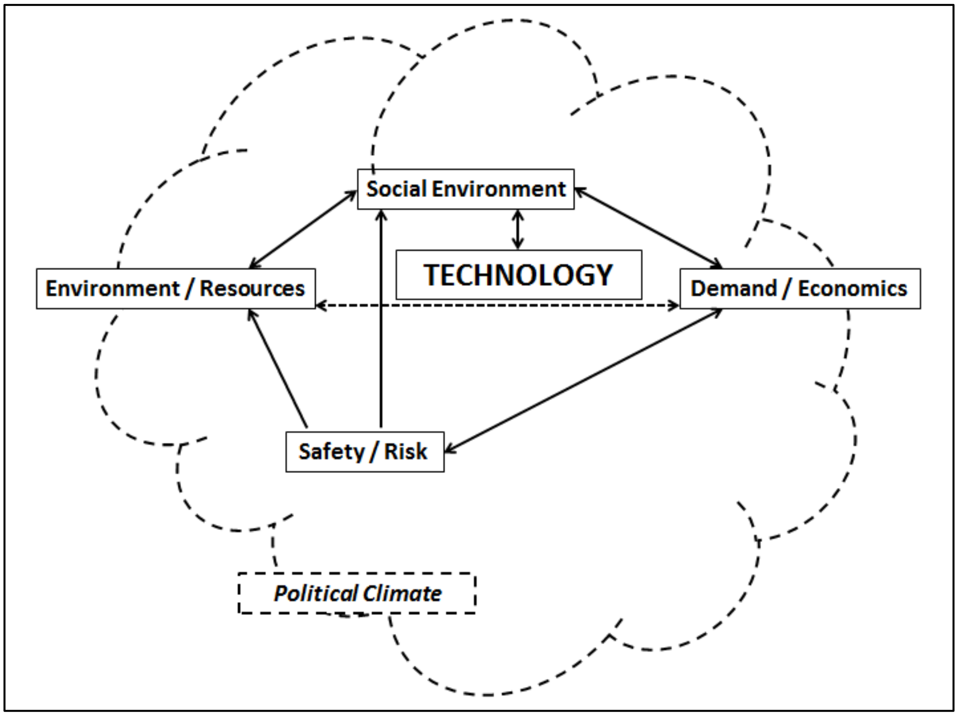

Figure 5.1 The Socio-Political Ecology Framework

5.1 The Early Days

Figure 5.2 The Construction of Hanford[2]

The story of Hanford began in 1942 and continues to this day. It is the story of what happened to 670 square miles of irrigated farm land in eastern Washington that has left much of it designated a toxic “Superfund” site, awaiting remediation.[3] The area once fell within the usual and accustomed hunting and fishing grounds of the Wanapum, a Native American tribe that had never signed a treaty with the U.S. government and was never confined to a reservation. Clever marketing campaigns enticed early white settlers to stake their claims to the land with pictures of heavily laden fruit trees and paragraphs promising that “[t]he man who owns his own fruit ranch in this valley is one of the most independent men in the world . . . He is dependent on no man . . ."[4] Families from Sweden, Germany, France, Iowa, the Dakotas, Nebraska, and Montana ventured west to try their luck at farming.[5] The towns of White Bluffs, Hanford, Horn Rapids, and Richland soon appeared on maps.

As explained in Chapter 1 of this dissertation, during World War II, with the blessing of the U.S. government, the world's top scientists and the U.S. Army Corp of Engineers under Major General Leslie Groves undertook a top secret project to develop an atomic bomb (the "Manhattan Project"). The project required several sites, including one where plutonium would be produced from natural uranium in a nuclear reactor. Lieutenant Colonel Frank Matthias and two companions from the DuPont Company set out on a mission to find an uninhabited and roadless rectangle of land measuring about 20 by 28 miles in size, with no towns of more than 1,000 on the land around the site. The site had to be one with plenty of relatively pure and low temperature water, and with access to a lot of electricity. The site also needed to have a mild climate, solid ground, and ample gravel available.[6]

> I thought that the site was perfect the first time I saw it . . . We flew over the Rattlesnake Hills and over up to the river. I saw the whole site on that flight . . . It had so much in favor of it. An area with almost no people, fairly undeveloped . . . I said, "I think we have found it . . ."
>
> Lt. Col. Frank Matthias[7]

That decision set off a series of events that began with the condemnation of 3,000 tracts of land under the War Powers Act, and the eviction of about 2,000 families.[8]

To Matthias and Federal Land Bank appraisers, the farms seemed of little value, and Matthias recalled in later conversations that people departed in an orderly fashion.[9] Indeed, those given two weeks' notice had little opportunity to argue. Some felt it was their patriotic duty in a time of war to accept the compensation offered.

> In March, 1943, when I was about 22, we received a letter from the government saying that we would have to move in 30 days. It was a terrible shock. I can't describe it. It was unbelievable. The only thing that made it credible to us was because of the war. Our town had been chosen for the war effort. We were so patriotic. Although we could go along with that idea, it was still a terrible blow. Even to think about it now, I can't even describe it. In spite of our patriotism . . .
>
> They appraised my father's 30 acres at $1,700, and the final settlement was $3,200 after the fruit loan of $500 or $600 was paid off. We also had 40 acres at the base of Rattlesnake Mountain, which my uncle and father purchased as an oil investment . . . For this land we were offered 25 cents an acre. We later received $1 an acre or $40 in all.
>
> The price offered for both acreages was ridiculous.
>
> Ridiculous!
>
> Annette Heriford, former resident of the town of Hanford[10]

However, many landowners who had spent years coaxing alfalfa, mint, cherry, apple, pear, and peach trees out of the dry ground did not go without a fight. Some stood on their porches with shotguns; others resorted to the court system to try to recoup some of the value of what they were losing.

> It came like a bombshell. They announced they were taking the whole valley. For what? We didn't know. At that time, the farmers were short of money and didn't have any place to go, really. So eventually the government appraised it and put the money in escrow for the landowners to draw on. This was estimated as their just compensation. What they did, they brought in Federal Land Bank people from clear out of the state Montana or elsewhere. They didn't understand the valley or fruit and they didn't think much of the valley and they brought in terribly low appraisals.
>
> Highway robbery!
>
> One case I handled, they went to a guy that had had a heart attack and was in his bed. Got him to sign off on property for what wouldn't even

> pay for the crop that was growing on it. I actually took it on the basis of fraud with the federal judge and he set aside the whole deal and awarded the family what was proper.
>
> Lloyd Wiehl, Attorney in Yakima, WA[11]

In many cases, the out-buildings, the value of crops *at the time of the taking*, and fencing had not been taken into account in the appraisals of the land tracts. Local irrigation districts and the farmers and veterans associations protested the low value of assessments.[12] Adjudication ran on for months. By the fall of 1943, land acquisition had ground to a virtual halt. Trials began in October 1943 and continued through September 1944. The juries consistently awarded the landowners money "greatly in excess of the amounts established in appraisals."[13] Eventually, to avoid more jury trials and even further delays in the Army taking possession of the land, appraisers made adjustments to the appraised values of the tracts, usually an increase of 20% over the original value.[14]

> [T]he question asked is how we feel about it and whether or not we were bitter. My answer is, "Disappointed." Not bitter, but disappointed, because it had to be done somewhere . . . There was a good deal of urgency about the time. It had to be done quick. And quick meant sometimes that some people get hurt. We just feel that we got hurt.
>
> Walt Grisham, member of the Air Force in England during World War II when his parents were told to leave their farm[15]

Once titles had been secured to the requisite land, the Army and DuPont demolished most of the existing buildings, and brought in trainloads of tradesmen to build Hanford Camp--the temporary housing for equally temporary construction workers--and the Hanford Engineer Works, a collection of nuclear reactors and plutonium separation facilities for making the plutonium for atomic weapons. The map shown in Figure 5.3 below indicates the locations of the Hanford's World War II facilities. Nuclear reactors were built in the 100 area along the Columbia River, the 200 area housed plutonium separation facilities, and administrative buildings and research laboratories were located in the 300 area.

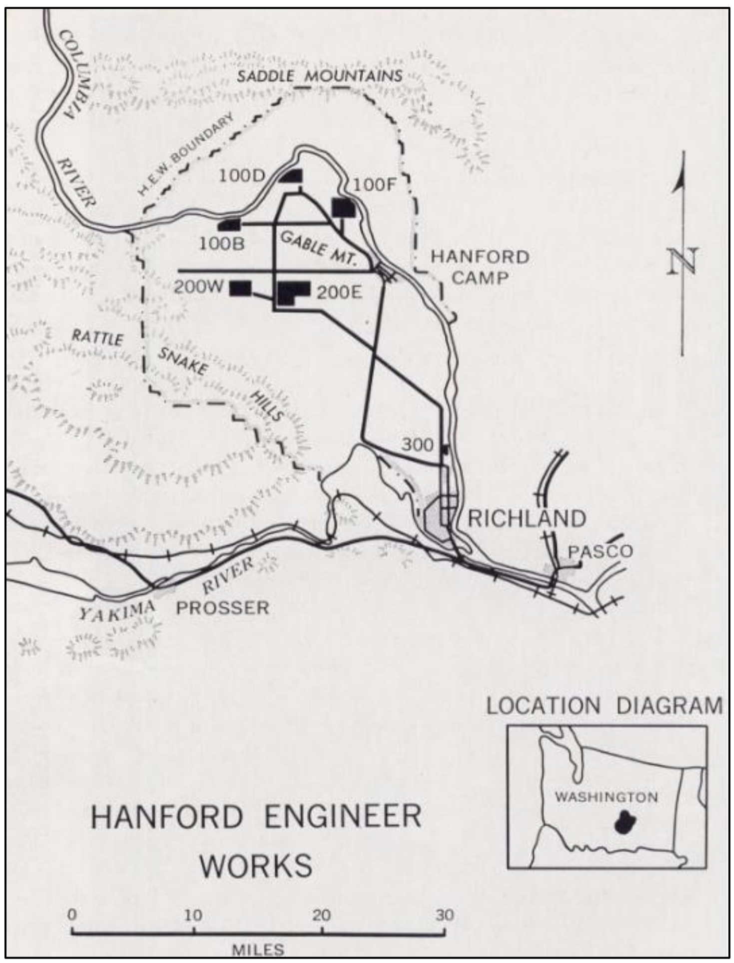

Figure 5.3 The Hanford Engineer Works, World War II[16]

Hanford Camp provided the bare essentials for the initial wave of construction workers and other start-up personnel at Hanford. "During the life of Hanford Camp, a total of 1,176 buildings and 9 service facilities were constructed to house, feed and provide the necessary habitable requirements for the construction workers and families . . ."[17] Those structures included 831 bunk houses (subdivided into areas for men and women, blacks and whites), 19 mess halls, 14 commercial stores, two laundries, four commissary buildings, two churches/community buildings, two theaters, a bank, a post office, spaces for 146 trailer/campers, and other structures. For two years, Hanford Camp was a city unto itself.[18]

Recruiters from the Army and DuPont combed the country to entice millwrights, woodworkers, pipefitters, electricians, machine operators, truck drivers, auto mechanics, surveyors, secretaries, cooks, telephone operators, physicians, nurses, and a wide variety of other laborers to make the journey to Hanford.[19] The map in Figure 5.4 below shows the extent of the recruitment activities. Most able bodied young men had already been drafted into the Armed Services, so recruiters appeared wherever they heard another War Manpower Commission job was ending, train tickets and travel itinerary in hand. If people were willing and able, they gave them a chance at a job at Hanford.

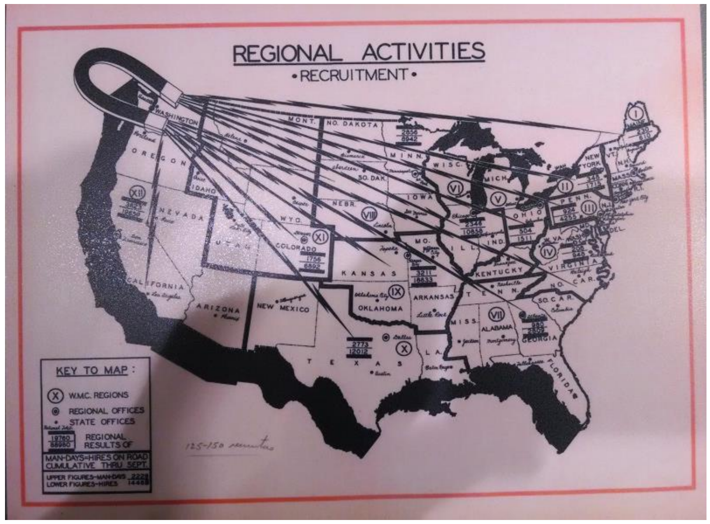

Figure 5.4 Hanford Recruiting Map[20]

As an added enticement, at a time when common laborers received $0.25/hour - $0.35/hour, DuPont offered $1.00/hour.[21] Skilled laborers could receive $15/day versus the more typical $10/day.[22] Unfortunately, none of the recruiters could tell the newcomers the exact nature of the job for which they were signing on. Even so, between 1943 and 1945 DuPont conducted over 262,000 interviews and hired 94,000 of those.[23] People with ties to the Communist Party or other shady political affiliations were turned down, as were law-breakers and known troublemakers.

Newcomers, often from the South, had not been prepared for the conditions they faced at Hanford.

> The recruiting posters lured people to come to 'the evergreen state of Washington, sparkling rivers, snowcapped (sic) peaks, wonderful fishing and hunting.' But what did you find? A desert with tumbleweed and jackrabbits . . . What a shock when they ride past miles of empty desert and arrive at this huge construction camp at the old Hanford town site.
>
> Steve Buckingham[24]

> People, including me, came out here thinking Washington was the Evergreen State, and got dumped in a desert. I remember my boss came in one day and he said, "Well, Rob, we got two people on the rolls today. We hired 650 and 648 quit."
>
> Robley "Rob" Johnson, DuPont employee from Gopher Ordnance Works, a powder plant near St. Paul[25]

Dust storms could be so severe that some job-seekers never even stayed the night. Trains would arrive in Pasco, WA in the middle of the night, after a short sleep, new employees would be given a hearty breakfast, and then bussed to the work site. Despite the promise of high pay, the turnover rate at Hanford stood at about 20%.[26]

Suffering the same fate as the residents of White Bluff, Hanford, and the area farms, the people living in Richland, WA had until November 15, 1943 to vacate the town, and all but a few structures were bulldozed to make way for a new town created for the white collar workers of Hanford.[27] The Army wanted to erect a city of barracks and military-style facilities. Compact housing would make it easier to keep people under control--for security reasons. DuPont executives argued that in order to attract and retain quality engineers and scientists and their families, they needed to create a town with comfortable single family homes with yards, schools, shops, and places of entertainment.[28] DuPont executives aimed to keep employees content; the Army brass worried about the costs of this new town and how to justify them during a time of war.[29] In the end, DuPont won out on most of the design criteria. Groundbreaking for the new Richland took place in March, 1943.[30] DuPont offered its employees a choice of stock homes--quickly nicknamed the "ABC Houses"--depending on their needs and availability. The rental price included coal for the furnace, water, electricity, and a shared lawn mower. Between 1943 and 1945, employees might select from the options listed in Table 5.1 below:

Table 5.1 "ABC" Homes, 1943 – 1945 Availability[31]

Type of Structure	Total Sq. Ft.	Bedrooms	Stories	Number Built
"A" Duplex	1175	2	2	408
"B" Duplex	882	2	1	520
"D" House	1587	4	1.5	8
"E" House	1201	3	1	84
"F" House	1216	3	1	250
"G" House	1503	4	2	8
"H" House	1070	3	1	250
"J" Women's Dormitory				17
"K" Men's Dormitory				8
"L" House	1536	4	2	44

In parallel, the DuPont Traffic and Transportation Departments--which consolidated the transfer of DuPont employees, their families, household effects and automobiles through Union Station in Chicago--made the following arrangements between April and December 1944 as outlined in Table 5.2 below:

Table 5.2 Transportation Arrangements, April – December 1944[32]

Arrangement Type	**Quantity**
Household movements	496
Automobile movements	85
Rail reservations	1736
Air Reservations	3
Passengers accommodated at the Union Station Lounge in Chicago (equipped with cots, chairs, writing tables, lavatory facilities)	1768

In 1943, the new Richland had a population of 240. By 1944, the DuPont's employees, scientists from the Metallurgical laboratory in Chicago, and others, helped swell the population to 11,000. By 1945, there were 13,000 residents in Richland.[33] Richland became the public face of the very secret Hanford: Clean and neat, populated by white, well-educated, middle class families with husbands who worked each day at Hanford, and wives who attended social engagements, played bridge, and swept up the perpetual layers of dust.

Yet few people knew the real reason for all the activity at Hanford.

> There were a lot of rumors about what was going on at Hanford. Everything was coming in, nothing was going out. And some people said, "Oh, that's a sandpaper factory. They hold up a glued sheet of paper and the dust coats it." Others said that the gigantic facilities rising from the desert were going to be FDR's winter palace.
>
> Roger Rohrbacher[34]

Even Matthias fabricated a story about the new explosives DuPont was developing at the site, to throw reporters off the scent. He claimed the new explosive would be "stronger than gun power, dynamite or nitroglycerine."[35] No one questioned his story.

General Groves insisted on the utmost levels of security and secrecy regarding the Manhattan project. He limited his discussions of its various aspects to people who absolutely needed to know, and would not even discuss them with those who might interfere with the work (including members of Congress and Vice President Truman).[36] He adhered to a strict rule of compartmentalization of knowledge: ". . . each man should know everything he needed to know to do his job and nothing else."[37] That also meant workers at Hanford understood what to do and how, but not why.[38] They were instructed not to ask those kinds of questions. According to Groves, a clear focus on the task at hand improved not only security, but also efficiency on the job.[39] Efficiency was needed to complete construction of the reactors and plutonium separation facilities, and to produce the amount of 95% pure plutonium needed to fuel an atomic bomb: 13.5 lbs., about the size of a large orange.[40]

Because of the strict compartmentalization of information, supervisors relayed the details of a days' assignments orally or through rough sketches.[41] Changes to designs or layouts were communicated in the same manner. Tradesmen had to invent the tools and equipment needed build something that had never been built before. They used their ingenuity and hands-on experience to translate the ideas of scientists and engineers into reality. The problems they faced did have mechanical solutions. "They presented us with what they needed and we went out and built it" (Clark Reitnauer).[42] That included using converted woodworking machines to mill high purity graphite blocks to a 4 x 4 x 48 inch size with a 0.39 inch bevel along the long edge.[43] Tolerances allowed for the blocks were "unheard of": +/- 0.006 inch in the length, +/- 0.005 inch in cross section, and +/- 0.004 inch in "squareness."[44] And that was well before computers and calculators took over the workplace.[45]

When the bombs dropped on Japan, Hanford's role in the war effort was secret no more. To most employees, it came as a complete surprise.

> When I got back to Alabama, people there knew more about what was happening out in Hanford than I did, and I was working there . . . Someone said, "That's what you were all making"—we killed people . . . That really shocked me!
>
> Luzell Johnson, construction worker, cement finisher[46]

Still, others worried about their pledge to keep secret about their work at Hanford.

> My wife and I had gone on a vacation trip up to Mt. Rainier. All of a sudden this information became available—we read in the newspaper that a bomb has been dropped and the President has announced so much information. So we wondered, how much can we talk about? Well, we decided we'd better be quiet about it; don't say anything. We got a frantic telephone call from my supervisor . . . and he says "Don't say anything!" . . . In fact, I don't think we told people we even worked at Hanford, so we escaped any consequences.
>
> Monty Stratton[47]

Most people working at Hanford felt a tinge of sadness that so many people died when the bombs dropped, but also believed that the bombs saved the lives of Americans, allied and enemy soldiers. Herb Depke, just a child when his family transferred from DuPont's plant in Danville, IL to Hanford, recalls his father being drafted into the Navy.

> So Dad trained for the invasion of Japan. Fortunately that invasion did not happen . . . the atomic bomb really saved his life. Here is a man

who worked in the Manhattan Project and wound up having the atomic bomb save his life.

Herb Depke[48]

All of my friends were over there either in Germany or in the Pacific, and I would certainly have no hesitation in sacrificing any number of the enemy to save even a small number of my contemporaries. But the final thing is that I believed at the time--and still believe more and more --that the bomb saved a lot of American lives and Japanese lives . . . because it ended the war so abruptly, and it was the only way in which that quick an end could have been brought to the war.

Warren Nyer, Physicist[49]

Although the stories of the early days of Hanford usually focus on the partnership between the Army and DuPont, and the pressures of war and the making of the bomb, people played an enormous role in this stage of its history. Recall the Heidermans, Kass', Riersons, Bruggermans, and other families evicted by the U.S. Army; the 50,000 construction workers who labored to tame the desert dust and turn 780,000 cubic yards of concrete into working nuclear reactors, separation facilities, and laboratories;[50] scientists like Dr. Enrico Fermi and Dr. Leona Marshall Libby who stayed close at hand to ensure the B reactor started up as planned in 1944; the men who operated the reactors; the women who served as chemists on site; and Colonel Frank Matthias who hand carried the first batch of plutonium from Hanford to Los Alamos, New Mexico by train. These examples underscore the importance of the Social Environment in the Socio-Political Ecology framework. In addition, in this case the Political Climate did not serve as the backdrop against which the technology developed, but was a major player in the moving the technology from the experimental, laboratory stage to production. Because of the close linkage between the war effort and the creation of Hanford and arrow linking Political Climate and Technology has been added to the Socio-Political Ecology framework shown in Figure 5.5 below. Likewise, an arrow has been added linking Political Climate and Demand/Economics due to the ongoing tensions between rapid deployment of the technology, build-up of manpower, and construction at the site, and U.S. Army requirements to keep costs down in a time of war. In the end, for this first part of the history of Hanford, the Political Climate, Technology, and the Social Environment stand out as key factors in the Socio-Political Ecology Framework. This is shown by the red dashed ellipsis in Figure 5.5 below.

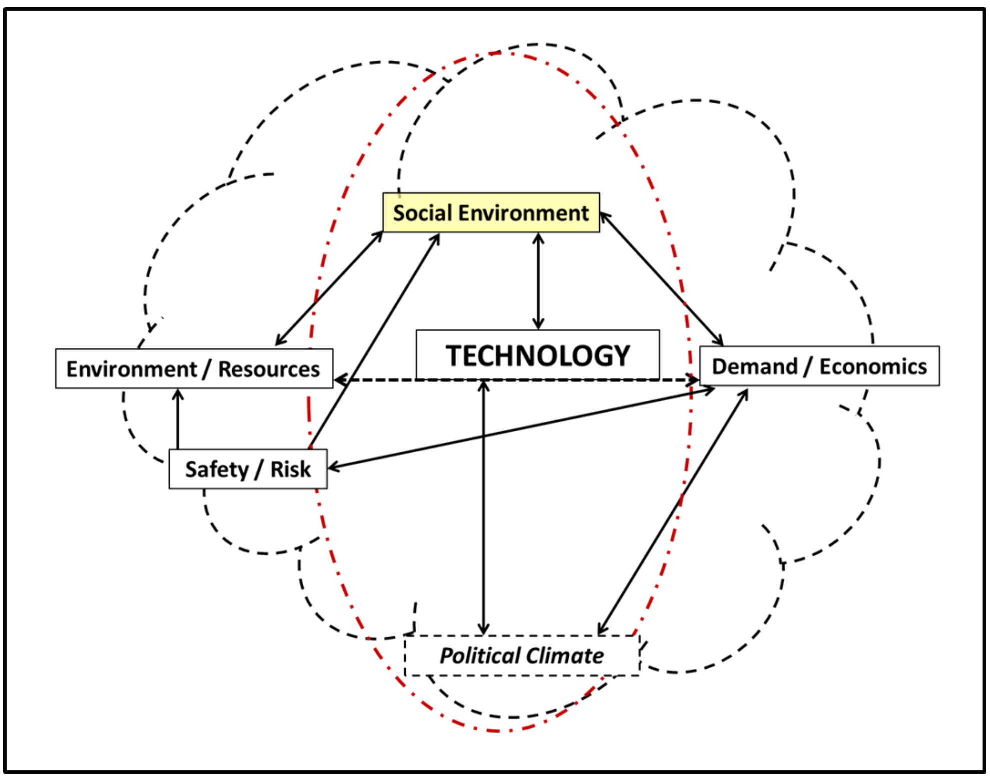

Figure 5.5   Socio-Political Ecology of World War II Hanford

5.2 Post World War II Hanford

The end of World War II brought many changes to Hanford. Hanford Camp closed in February 1945, and, like the towns it replaced, was torn down.

> It was hard then, really hard, for anyone looking at that place, sagebrush and sand, a few goats, to visualize the 51,000 people who had lived there at the peak of it.
>
> Jane Jones Hutchinson, Secretary[51]

In September 1945, 10,000 contractors worked at Hanford. Fifteen months later that number had dropped to 5,000.[52] Lt. Gen. Frederick Clarke replaced Col. Matthias as the supervisor at Hanford.[53] DuPont turned over the reins to General Electric (GE) effective September 1, 1946.[54] The newly formed U.S. Atomic Energy Commission (U.S. AEC) assumed responsibility for all nuclear weapons sites in 1947. For a time the Army set up a missile defense system and anti-aircraft artillery sites around the perimeter of Hanford to protect the facilities from attack.[55] Soldiers manning those sites lived in conditions similar to those at Hanford Camp in the 1940s.

Although much of the focus around the world had shifted to finding civilian uses of the power of the atom (as explained in Chapter 1), growing concerns over the threat from the Soviet Union and then Korea prompted the expansion of Hanford's plutonium production facilities. Five reactors were added to the site between 1947 and 1955.[56] Hanford's reduction-oxidation plant (REDOX) opened in 1952.[57] It housed the world's first continuous operation for removing plutonium from a reactor's spent fuel, shortening the time needed and increasing the efficiency of the process. Yet another facility to extract plutonium and uranium from irradiated fuel was added in 1956 (PUREX).[58] Both the REDOX and PUREX facilities were located in the "200" area of Hanford, on the central plateau, shown in Figure 5.3 above.

Blue collar workers who had chosen to stay in the area had settled into Kennewick, Pasco, or Prosser; transient construction workers and their families moved into a quickly erected a semi-permanent town, North Richland Construction Camp—a town that in many ways resembled the original Hanford Camp.

> When I lived there, in the late '40s and early '50s, North Richland was mostly a big trailer camp for the construction workers. There was a canopy for each trailer, which was pretty essential since many weren't that weather tight. I remember climbing on top of one of the canopy's and it seemed that all I could see was other trailers . . . Each block contained a wash house, which I believe had washing machines in one half, and showers, toilets and sinks in the other, very much like on a military base. On a warm summer night, the lights of the wishes (sic) would attract the june (sic) bugs, many of which died in the sinks so that you had to scoop out the sinks in the morning to wash and shave.
>
> North Richland was a pretty self sufficient (sic) community with a drug store . . . a grocery store, a movie theater (the North Star), and a Clothing Store (Herman's) where I worked after school. They also had a couple of really huge cafeterias, also called beer halls, where you could get breakfast in the morning and a meal with pitchers of beer in the evening. I seem to recall that the number of gallons of beer consumed each day was a classified military secret even in those days.
>
> Besides all the trailers, there were also a number of houses near the river that were for the construction supers, who were a little more permanent than the trailer folks. And for the really transient folk, there were the barracks. The men's barracks were open and accessible, but the women's barracks was surrounded by a tall chain link fence. For a brief time, I stayed with my dad in the barracks. Sleeping two on an army cot wasn't easy.
>
> Dick Epler[59]

For the white collar employees who elected to take jobs with GE, Richland became a permanent home. Wives began fixing up the "ABC" houses, making curtains for the windows, replacing the furniture the Army and DuPont had provided with their own furnishings, planting gardens and trees. When the U.S. AEC began to dispose of properties acquired during the war, including the towns of Richland and Oak Ridge, TN, residents had the opportunity to purchase the homes and really settle down. Initially, locals complained about the high appraisals.[60] Prices came down on about half the properties and people did invest. Jerry Yesberger, health physicist at Hanford, purchased his "B" style ranch house for $6,500.[61] Donna Jackson related the story of friends John and Mary who paid a bit more: $10,500 for their ranch home—a price reduced by $800 if they committed to stay for a certain length of time.[62]

After the second construction push, employment levels at Hanford and the population of the region leveled out. The fate of Hanford and the Tri-Cities (Richland, Kennewick, and Pasco) in the decades that followed continued to be tied to decisions made in Washington D.C. When the country needed to expand its stockpiles of atomic armaments, operations at Hanford flourished. When decisions were made to draw down those stockpiles, or when reactors built in the 1940s had reached the end of their useful lives, facilities at Hanford began to close down. Residents of Richland give credit to one particular individual, Sam Volpentest, for continuing to keep Hanford relevant.[63] Sam knew the decision-makers at the state and federal level and was able to funnel projects and dollars to eastern Washington. In a speech on the floor of the U.S. Senate after his death in 2005, Washington Sen. Maria Cantwell praised Sam for bringing to Hanford the Pacific Northwest National Laboratory, the N-Reactor Hanford Generating Plant, and the Fast Flux Test Facility, a sodium cooled research reactor.[64]

The Washington Public Power Supply System (WPPSS) did make an attempt to add commercial power reactors to the Hanford site in the 1970s. An overly optimistic demand forecast, management problems, construction defects, cost overruns, and a default on the municipal bonds issued to finance the construction resulted in only one of the proposed reactors being finished—the one now referred to as the Columbia Generating Station.[65] Despite the efforts of many individuals, by 1989 the Hanford site had transitioned out of operations and into its clean-up phase. The timeline at the end of this chapter (Table 5.3) details many of the events that occurred over the more than 70 years at Hanford and in neighboring Richland.

5.3 The Clean-Up

During the on-going clean-up phase of Hanford's life story, the focus has expanded to include all elements of the Socio-Political Ecology framework, shown in Figure 5.6 below.

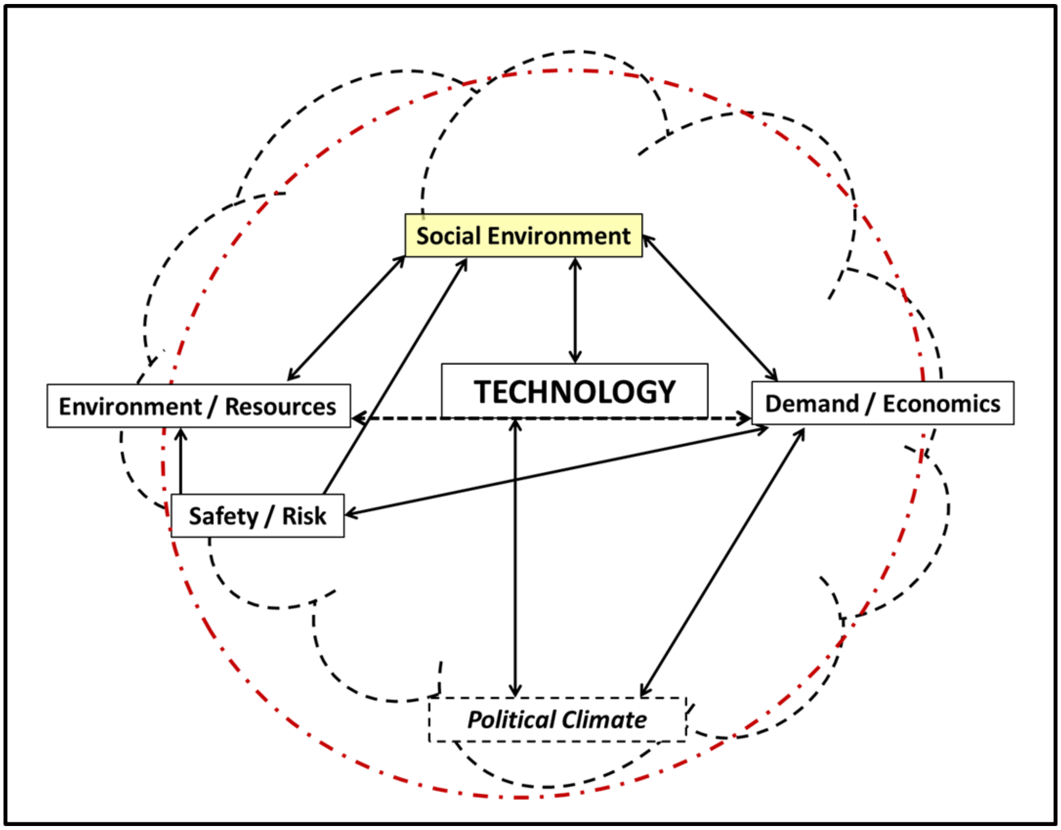

Figure 5.6 The Socio-Political Ecology of Hanford's Clean-up

Governmental agencies at all levels (a fundamental part of the Political Climate) continue to play an important role. A Tri-Party Agreement was signed between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, and the State of Washington Department of Ecology in May 1989. The Agreement set out to guarantee cooperation and exchange of information among all parties involved—government and civilian; to ensure compliance with the Resource Conservation and Recovery Act of 1976 and the Hazardous and Solid Waste Amendments added in 1984; to develop and implement procedures in accordance with the Comprehensive Environmental Response, Compensation and Liability Act ("Superfund") of 1980; to ensure compliance with Washington State's requirements regarding permitting, land disposal restrictions, and the like; and to safeguard "public health, welfare, and the environment."[66] Government agencies, in partnership with a variety of contractors, set out to identify the issues at Hanford and propose preferred plans, engage the public and Native American Tribes in conversation about those plans, and then take action to remediate the contamination at Hanford.

Environment comes into play during the clean-up because of the sheer volume of radioactive material that was released into the Columbia River, the air, and the ground during the decades of operation of the facilities. The reactors at Hanford all used water from the river as a coolant. That water sat in retention ponds for eight hours after exiting the reactors to allow radioactive materials to decay. "However, it is true that there were still radioactive materials there and they were picked up by the various plant organisms, which in turn were eaten by the fish. The fish became very mildly contaminated with radioactivity."[67] The elevated water temperatures also affected the levels of bacteria in the water. Anyone catching and eating the fish would also ingest those same radioactive and bacterial substances. In addition, people who used water from the river for irrigation or drinking, or who ingested water while swimming, could suffer the same fate.

Air releases of toxic materials first became known to the public in 1986 when the DOE released thousands of pages of history of the Hanford site to comply with a request through the Freedom of Information Act.[68] Between 1944 and 1970, 10 million curies of radioactive isotopes had been discharged into the atmosphere as a result of the operation of reactors B, C, D, DR, F, H, KE, and KW. The addition of N reactor contributed another 2 million curies.[69] The most famous one-time release has become known as the “Green Run.” In December 1949, the Department of Defense conducted an experiment to track the radioactive emissions of spent reactor fuel that had not been allowed to cool for more than two weeks after leaving the reactors before being processed (“green” fuel).[70] The aim was to see if instruments would be able to trace similar emissions from Soviet atomic weapons facilities and if so, if they could calculate the amount of plutonium being manufactured.[71] In the process, about 11,000 curies of iodine 131 were released over the site and surrounding lands. (One curie equals 37 billion disintegrations of a radioactive element per second.) Winds and rain carried the radioactive iodine as far as Spokane to the north and Walla Walla to the east, and onto the neatly tended gardens of Richland and Kennewick to the south. Other releases did not receive such catchy names.

> . . . one of the stories I covered . . . I was out near the tank farms . . . It has a 300-foot-tall atmospheric tower at that site . . . going downwind from that 300-foot-tall tower were, number one, four or five 200-foot-tall towers and then five or six or seven 100-foot-tall towers. They would regularly release very small quantities of radioactive iodine, most usually put into colored smoke so they could track both the visual as well as radiation and see how long it took to go downwind and disperse. Just to show you how we were at the time, the photographer and I who were covering that piece as a story thought, well not only did we want to shoot it so you can see it go, but get underneath it so you could watch it as it--It's not a very smart thing to do today, but at the time it seemed like a pretty good idea to be able to watch that stuff as it drifted and deposited. So, we did the story. [U.S.] AEC never let us release it, but we kept the story internally for quite a number of years. I don't know what happened to it now, but those kind of things went on fairly often. You need to know where radiation goes, and that was a piece of it.
>
> Gary Peterson[72]

Twenty-five million cubic feet of solid waste lie buried, or in above-ground waste storage facilities, at Hanford.[73] This waste includes coveralls worn by Hanford workers, rags, gloves, contaminated equipment, and tools. Prior to 1970, workers mixed together chemicals and materials contaminated with uranium, plutonium and other radioactive isotopes, making it difficult (and dangerous) to determine exactly what lies below the surface of many of the 75 solid waste burial grounds.[74] Much of the liquid waste from the early experiments in the 300 area laboratories (in the southwest of Hanford, see Figure 5.3), fed into a process sewer connected to a pond adjacent to that site.[75] Other radioactive waste from fuel experiments conducted in the 1960s has been found in steel barrels and metal caissons buried near that area. In addition, "[s]ome large machines, including contaminated railroad cars and locomotives, are stored in underground tunnels such as adjoining the PUREX Plant."[76]

Figure 5.7 Hanford Area 300 Burial Site[77]

For disposal of liquid wastes, early DuPont employees dug "reverse wells" into the ground and poured in those wastes.[78] Other methods of disposing of liquefied wastes over the decades have included 1. Pouring them into open ponds; 2. Digging trenches which would be backfilled after waste was added; 3. Pouring them into French Drains; 4. Letting the waste drain through cribs (covered, open-ground waste filtration beds).[79] The liquids from those deposits have migrated through the soils toward the groundwater layer below and the Columbia River. Hexavalent chromium, strontium, technetium 99, uranium, iodine 129, tritium, and nitrate are among the elements now targeted for monitoring and clean up.[80]

Hanford's tank farms tend to grab the newspaper headlines: from "Secrecy Tied to Hanford Tanks' Trouble" (*The New York Times*, 1990)[81], to "Wine country's Nuclear Threat" (The Daily Beast, 2015),[82] to "Nuclear Leak at Washington's Infamous Hanford Site is CATASTROPHIC, Former Worker Claims, as Eight Inches of Radioactive Waste Escapes Core of 'The World's s Safest' Tank" (The Daily Mail, 2016).[83] These tanks hold the spent fuel from the reactors at Hanford as well as the waste from reprocessing that fuel. Each holds between 55,000 gallons and 1.1 million gallons of waste.[84] The waste is highly radioactive and will remain so for hundreds of thousands of years. It can also generate a significant amount of heat as the waste undergoes radioactive decay.

In a 1980 report, the DOE confirmed that the single walled tanks first began leaking in 1958. Of the 149 tanks built between 1943 and 1964, those not heat treated for stress relief, "24 single shell tanks have been classified as confirmed leakers, 34 single shell tanks have been classified to be of questionable integrity."[85] The report expressed concern over the adequacy of monitoring of the tanks, including a potential cover-up of leakage from several of the tanks.[86] At the time seven double walled, heat-treated tanks had been constructed and another 13 were being built. As of this writing more than 60 tanks have leaked roughly one million gallons of radioactive materials into the surrounding soils.[87] In 2016, 56 million gallons of liquid or semi-solid high-level waste remains stored in 177 tanks on the Hanford site. No one knows exactly what each tank contains. Even so, the Washington Department of Ecology has set January 31, 2043 as the target date to have removed as much of the material from the single walled tanks as possible and to close the single walled tank farms.[88]

While nuclear technology remains the central technology of interest in all three of the case studies of this dissertation, new technologies are being added to the Hanford site as part of the clean-up efforts. Continuing efforts to determine how to handle underground plumes of liquid contaminants involve increasingly complex computer modeling of fluid flow and transport through the soil layers and the risk of contaminating the groundwater. In addition, in 2000, Bechtel National, Inc. was awarded a contract to design and build a vitrification plant to form the wastes into glass bricks to stabilize the wastes, prevent them from seeping into the environment, and thus allow for their permanent storage.[89] Although vitrification had been discussed for use at Hanford since the 1960s[90], and AREVA uses a version for dealing with spent fuel in France, the details for the Hanford site have yet to be finalized. A December 19, 2012 report from the U.S. Government Accountability Office indicated that some of the features of the Bechtel design did not meet DOE nuclear safety standards.[91] In addition, Bechtel had begun construction of the facility before the design was 90% complete, in violation of civilian nuclear industry guidelines. The project has been shut down until technical issues and design concerns can be resolved and the designs completed. Through mid-May 2105, $19 billion had been spent on the project, the estimated cost estimate for the facility had tripled, and the expected completion date had been extended well beyond its original target.[92]

The Hanford clean-up incorporates both the Risk and Safety factors of the Socio-Political Ecology Framework because of the extreme hazards associated with working the enormous volumes of radioactive materials on the site. Nine nuclear reactors had to be decommissioned; six have been “cocooned” -- demolished down to the reactor building and covered in steel and cement.[93] (B Reactor was designated a

National Historic Landmark and opened to the public as part of the Manhattan Project National Historic Park.) Despite its high toxicity, beryllium had been used in experimental work on aluminum alloys during the 1950s and in preparation of fuel rods for the N Reactor in later years.[94] Inhalation of even minute amounts of beryllium dust left over from those uses could cause allergic-like reactions or chronic beryllium disease, characterized by fatigue, shortness of breath, a dry cough, and chronic pain.[95] Due to the numbers of cases of the disease occurring at the site, in 1999 the DOE required all Hanford contractors to develop a Chronic Beryllium Disease Prevention Program.[96] Many failed to follow the new guidelines.[97] A new, site-wide program replaced the individual programs in 2009. However, for those employed at Hanford prior to the implementation of the new rules, it was too late. Approximately 300 people have developed beryllium related conditions from the employment at Hanford.[98] According to former Secretary of Energy Bill Richardson, "Priority one was production of our nuclear weapons. As a last priority, was the safety and health of the workers that built [those] weapons."[99]

Clean-up efforts at the "tank farm" have exposed another set of workers to toxic gases, sending some of them to local hospitals.[100] In fact, in July 2016, the Attorney General of Washington filed suit against the DOE and contractors at the site to better protect the workers against the hazards of the job.[101]

As might be expected, the Social Environment factor of the Socio-Political Ecology framework also plays a big role in the Hanford clean-up. The preceding paragraphs have described the clean-up activities at the site and the hazards many people face in doing that work. As of June 2015, over 9,250 federal and contracted employees worked at the Hanford site.[102] Much earlier, in 1990, people of the region took the DOE, DuPont, GE, and other contractors who operated the Hanford site to court over the releases of radiation that had occurred over the years. A panel of scientists released information that people living in communities near Spokane, WA received much higher doses of radiation during the 1940s and 1950s than was previously thought.[103] It wasn't until the release of that report that people realized that when released into the atmosphere the iodine broke down into three chemical forms, two of which could be carried long distances. The people were also responding to the thousands of pages of information released in 1986 that documented the volumes of radioactive material released over the years. They learned about the Green Run, the release of 27,000 curies of iodine 131 during the growing season of 1951 when filters on the reactors failed, and releases of ruthenium between 1952 and 1954.[104] They made connections to thyroid cancers diagnosed in 31-year olds, brain tumors in 26-year olds, and cancers that spread to livers, kidneys, and bones.[105] However, a dose response study conducted by the Fred Hutchinson Cancer Research Institute in Seattle, WA concluded that while there was indeed a surprising amount of thyroid disease in eastern Washington, the incidence of thyroid cancers among its study participants was comparable to incidences among non-exposed populations.[106] To succeed in their lawsuit, the local people, "Downwinders," had to prove their diseases resulted from exposure to emissions from Hanford and that they did indeed have cancer. (Many had ingested iodine by drinking milk from the backyard cow as children.[107]) The suit was finally settled in October 2015, long after some plaintiffs had died and both sides had spent tens of millions of dollars pressing their cases.[108]

The funds spent fighting and settling those lawsuits underscore just one aspect of the Economics factor of the Socio-Political Ecology Framework. Another aspect is the cost of the clean-up itself. Consider just one part of the project, the vitrification facility. In 1998, the DOE awarded the contract for to British Nuclear Fuels, Ltd. after its $3.2 billion bid to build and promise to have 10% of the waste treated by 2018.[109] After two years, British Nuclear Fuels revised their estimate to $15.2 billion due to the requirement that the company obtain private financing for the project.[110] The DOE cancelled the contract. Bechtel won the next round of bidding with an estimated that plant construction cost of about $4.3 billion.[111] Bechtel also signed a lucrative 11 year, cost-plus-incentive-fee contract, common in defense work.[112] To keep on schedule to meet a 2028 deadline to complete the facility and to keep costs down, the DOE asked Bechtel to use a fast-track, design/build approach to the project, but that has led to problems with the design and materials, and issues with adhering to nuclear industry safety standards.[113] In 2006 Bechtel estimated cost for the facility to be $11.3 billion.[114] Current estimates have surpassed $12.3 billion, according to the DOE's Assistant Secretary for Environmental Management.[115]

5.4 Concluding Thoughts

The final chapter of the history of Hanford has yet to be written. Table 5.3 below provides a more detailed look at the history of Hanford and Richland, and the events to date that have shaped the land and the people of that area of eastern Washington. The intense and patriotic push to develop a site and produce plutonium for atomic weapons for World War II gave way to a new mission during the Cold War to contribute to the growing U.S. nuclear weapons arsenal. The construction of new reactors and new chemical separation facilities followed. The addition of electrical generating technology and research laboratories to Hanford expanded the scope of operations and ensured Hanford a place in the every-changing nuclear technology landscape. Jobs created at Hanford and in the surrounding communities contributed to the economic growth of the region. However, decades of operations took a toll on the human and natural environments. The work carried out at Hanford has left behind a legacy of serious illnesses among workers and local residents, and unfathomable amounts of toxic waste with which current and future generations must contend.

In November 2015, the U.S. National Park Service and the Department of Energy opened portions of Hanford, Los Alamos, NM, and Oak Ridge, TN to the public as the Manhattan Project National Historic Park. At Hanford, former employees act as docents, taking great pride in explaining the role that Hanford played in both World War II and the Cold War, fabricating the plutonium for the weapons that kept the country safe and, later generating electricity to help power the state's big employers. The park boasts that it "served as the organizational model behind the remarkable achievements of American "big science" during the second half of the twentieth century."[116]

Chapter 6 turns to another large scale nuclear technology project: the Chernobyl Nuclear Power Plant. It too was part of an effort to achieve "progress" through the application of science, but at a different time and in a very different part of the world—the Soviet Union in the 1980s.

Table 5.3 An Overview of the History of Hanford

Phase	**Month**	**Year**	**Event**
Planning			
	Fall	1941	President Roosevelt committed to a crash program to build an atomic weapon
	Dec	1942	Scientists at the University of Chicago achieved the first controlled atomic reaction, using plutonium
	Dec	1942	Lieutenant Colonel Franklin T. Matthias identified an area near the towns of White Bluffs and Hanford, along the Columbia River and north of the Yakima River in eastern Washington as the place best suited to the needs of the Manhattan Project
		1942	DuPont company signed on to the Hanford project
	Feb	1943	U.S. War Department finalized plans to acquire the 670 square mile site
	March	1943	Landowners, homeowners, residents received notice that their land had been condemned and they had between 15 and 90 days to vacate
Construction			
	Spring	1943	Destruction of existing structures and construction of new buildings began at the Hanford site
	Aug	1943	Groundbreaking began for the water cooling plant for 100 area - B reactor
Operations			
	Feb	1944	Work began on B reactor itself
	Sept	1944	Plutonium production started at the B reactor
	Dec	1944	Plutonium processing started in the chemical separation areas: 200 - East and 200 - West
	Dec	1944	D Reactor Operational
	Feb	1945	F Reactor started up
	Feb	1945	First shipment of plutonium from Hanford by train for Los Alamos, New Mexico
	July	1945	The first plutonium bomb was detonated near Alamogordo, New Mexico
	Aug	1945	U.S. Army Air Corps dropped a uranium bomb on Hiroshima, Japan and a plutonium bomb on Nagasaki, Japan

Table 5.3 continued

	Aug	1945	People heard about the Manhattan Project for the first time
	Dec	1945	DuPont announced it would leave the Hanford project
	Sept	1946	General Electric (GE) assumed responsibility as primary contractor at Hanford
	Jan	1947	U.S. Atomic Energy Commission (U.S. AEC) took over from the U.S. Army as the government bureau in charge of Hanford
	June	1948	Richland Community Council held its first meeting as a part of the AEC attempt to "normalize" life in atomic towns constructed during WWII
	Oct	1949	H Reactor became operational
	Dec	1949	Green Run radiation release experiments occurred
	Oct	1950	DR reactor came on line
		1952	C Reactor started operations
	Jan	1952	REDOX facility began operating
	May	1953	Vitro Engineers assumed design responsibilities under GE
	June	1953	J.A. Jones assumed construction responsibilities under GE
	Jan	1955	K West reactor became operational
	April	1955	K East reactor started operations
		1955	Atomic Energy Commission Act passed, allowing the transfer of property in Richland to town residents
	Jan	1956	PUREX Separation Facility began operations
	June	1956	Senator Henry Jackson introduced the first of several bills into congress to authorize construction of the world's first dual purpose reactor at Hanford (plutonium and electricity production)
	June	1957	U.S. government sold the first of the "ABC" homes to private owners
	Jan	1958	Construction began on the Hanford dual purpose N reactor
	Dec	1958	Richland formally re-incorporated as a municipality in Washington

Table 5.3 continued

	Sept	1963	Pres. Kennedy visited Hanford to break ground on the electric generating plant adjoining the N reactor
	Dec	1963	N reactor began producing plutonium
	Jan	1964	Pres. Johnson announced that the U.S. AEC would shut down three reactors at Hanford
		1964	U.S. AEC announced that work at Hanford would be distributed among multiple contractors which would also be required to invest in diversifying the Tri-Cities economy
	Jan	1965	Battelle Memorial Institute (later Pacific Northwest National Labs (PNNL)) took over GE laboratory operations
	Aug	1965	Hanford Occupational Health Foundation assumed Industrial Medicine role from GE
	Sept	1965	Douglas United Nuclear (later United Nuclear Industries) took on some reactor and fuel fabrication responsibilities at Hanford
	Jan	1966	Isochem assumed chemical processing role from GE
	Jan	1967	U.S. AEC selected Hanford as the site for the Fast Flux Test Facility
	March	1967	U.S. AEC announced creation of the Hanford Arid Lands Ecology Reserve
	July	1967	Douglas United Nuclear took over operation of N reactor
	Sept	1967	Atlantic Richfield Hanford took over chemical processing from Isochem
	Feb	1970	Westinghouse Hanford assumed development of Fast Flux Test Facility from PNNL
	Jan	1971	Pres. Nixon announced Hanford's K East reactor would close, signaling the end of plutonium production by reactors constructed during WW II
	April	1973	United Nuclear Industries assumed responsibility for all production reactor operations
	Sept	1973	Washington Public Power Supply System (WPPSS) proposed construction of five commercial nuclear reactors in Washington, two on the Hanford site

Table 5.3 continued

	Oct	1977	Management of the site property turned over to the U.S. Department of Energy (DOE)
	Oct	1977	Rockwell Hanford took over chemical processing from Atlantic Richfield
	June	1981	Braun Hanford (BHU) assumed architectural and engineering duties
	March	1982	Kaiser Engineering replaced Braun for architectural and engineering services
	Nov	1983	The PUREX processing plant restarted at Hanford, to restock plutonium under Pres. Reagan and his Strategic Defense Initiative (SDI)
	Sept	1984	WPPSS reactor No. 2 at Hanford dedicated (now the Columbia Generating Station)
		1985	Federal judge ordered DOE to begin complying with national environmental protection laws at the Hanford site
	Feb	1986	DOE released 17,000 pages of material documenting the history of the Hanford site, including data on radiation releases into the environment
	Jan	1987	N reactor (which shared design features with Chernobyl) shut down
Legacy			
	May	1989	U.S. DOE, Environmental Protection Agency (EPA), Washington Department of Ecology signed the Hanford Federal Facility Agreement and Consent Order, creating a framework for the cleanup of Hanford: 30 years at an expected cost of $57 billion.
		1990	DOE conceded that emissions from Hanford during the 1940s and 1950s were high enough to cause cancer and other illnesses among residents in the Pacific Northwest.
		1990	First lawsuits by "Downwinders" filed against contractors working for the government at the Hanford site since 1943: DuPont, GE, Atlantic Richfield Hanford, Rockwell Hanford, United Nuclear.

Table 5.3 continued

	April	1994	Final results of the Hanford Environmental Dose Reconstruction Study released, showing substantial, chronic exposure through the 1950s to the area, including Spokane and northern Idaho
	Oct	1998	Fluor Daniel Hanford assumed site management and operations and signed contracts with another 13 subcontractors
	April	1999	DOE incorporated 50,000 acres north of the Columbia River into the Saddle Mountain National Wildlife Refuge
	Jan	2000	DOE admitted that workers at nuclear weapons facilities were exposed to chemicals and radiation that could cause illnesses and early death
	April	2000	Clinton administration proposed compensation plan for people who worked in nuclear weapons manufacture under the DOE
	June	2000	Pres. Clinton created the Hanford Reach National Monument providing protection from development for 50 miles of the Columbia River adjacent to the Hanford site
	Dec	2000	Fluor Hanford transitioned to clean up operations (with the 13 subcontractors assuming roles as well)
	Dec	2000	Bechtel was contracted to design, engineer, and construct a waste treatment plant
	Oct	2008	Chem2Hill assumed responsibility for cleanup and remediation of the central plateau
	April	2009	Washington Closure Hanford began work on river clean up
	May	2009	Mission Support Alliance took over site infrastructure and services
	Oct	2009	Washington River Protection Solutions assumed oversight of tank farm operations
		2010	Court ordered decree set 2040 as the date for all radioactive waste to be retrieved from Hanford and 2047 as the date by which it must be treated
		2013	Construction of waste treatment plant at Hanford halted after serious design flaws uncovered
	Oct	2015	Hanford Downwinders lawsuits finally settled

Table 5.3 continued

	July	2016	Washington Attorney General filed suit against DOE and Hanford contractors to better protect workers from continued exposure to toxic chemical vapors

ENDNOTES

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[2] Courtesy of the author, taken with permission at the exhibit "Black Life in Hanford," Northwest African American Museum, Seattle, WA, May 12, 2016.

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[42] Ibid., 39.

[43] U.S. Department of Energy, Assistant Secretary for Environmental Management, *Historic American Engineering Record, B Reactor*, 27.

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Chapter 6

CONTEXTUALIZING CHERNOBYL

> There you are: a normal person. A little person. You're just like everyone else—you go to work, you return from work. You get an average salary. Once a year go on vacation. You're a normal person! And then one day you're turned into a Chernobyl person, an animal that everyone's interested in, and that no one knows anything about. You want to be like everyone else, and now you can't. People look at you differently. They ask you: Was it scary? How did the station burn? What did you see? And, can you have children? Did your wife leave you? At first we were turned into animals. The very word Chernobyl is like a signal. Everyone turns their head to look. He's from there!
>
> Nikolai Kalugin[1]

6.1 Nuclear Technology in the USSR

Chapter 1 of this dissertation provided a brief overview of the early years of nuclear technology development in the former Soviet Union. According to the Western sources cited there, spies for the Soviet Union passed on designs and key secrets from the Manhattan project, information which greatly aided in the development of Soviet atomic weapons. In contrast, according to Soviet history, "[t]hanks to the painstaking effort of scientists the work was progressing fast . . . Thus, the four-year heroic effort of Soviet scientists and engineers allowed the Soviet Union to come on a par with the United States of America."[2] The end result was the same—the Soviets had the elements of their own atomic weapon well in hand by the end of the 1940s.

By 1954 the Soviets connected their first nuclear power plant to the national grid, the 5 MWe Obninsk station near Moscow.[3] Graphite-moderated and water cooled, it became the forerunner of the larger Reaktor Bolshoy Moshchnosty Kanalny (RBMK) built across the country. Also in the mid-1950s a number of new research institutes opened to explore weapons development as well as the issues of using the power of the atom for electricity generation and propulsion: The Institute of Theoretical and Experimental Physics, the Joined Institute of Nuclear Research, the Institute of Physics and Power Engineering, and the Research Institute of Inorganic Materials.[4] The Kurchatov Institute, named after Igor Kurchatov, the head of the Soviet nuclear program, focused during those years on construction of weapons, nuclear submarines, icebreaking ships, and the small scale reactors needed to support those uses.[5] Indeed, the Soviets devoted quite a number of their top scientists and engineers to nuclear technology innovation.

As explained in more detail in Appendix A, this combination of scientific proficiency and technological proficiency became a symbol of progress, of an advanced civilization.[6] Their application to finding new uses for the power of the atom was virtually unavoidable, especially when supported by the powerful centralized Soviet government. The Soviet Union needed widespread electrification to revolutionize agriculture, modernize industry, and support economic prosperity.[7] Advancing the peaceful use of the atom, harnessing its ability to produce electricity dovetailed with those goals. The Soviet State Committee for the Utilization of Atomic Energy had set up a research and development program into several promising reactor technologies following the success of the Obninsk station.[8] That program ultimately led to the opening of four 100 – 200 MWe prototype reactors in the early 1960s and a fast-flux research reactor.[9] The fast-flux, breeder reactor, capable of producing both electricity and plutonium fuel, was being developed as the future of the Soviet program. The prototype designs included the scaled up version of the graphite moderated/water cooled reactor (the RBMK) and a pressurized water reactor (a series later known as the Vodo-Vodyanoi Energetichesky Reaktor or VVER). Each design had its advantages. The VVER had its roots in submarine propulsion technology and drew on component with a proven track record.[10] It could help regulate the frequency and power of the grid, and provide both electricity and district or process heating.[11] The VVER required a very large pressure vessel with no longitudinal welds that would contain the high pressure steam. Only one factory in the country was capable of meeting the quality standards set for those vessels.[12] In contrast, RBMK reactor components could be fabricated at existing manufacturing plants—there was no need to develop specialized industrial facilities just for reactor parts.[13] The plant could be refueled while remaining online.[14] Another benefit of the RBMK design was the more than 100 primary circuits in place, a feature that would increase the safety of the system. Although the RBMK lacked a containment vessel to protect against the spread of radioactive material into the environment during an accident, and although the design suffered from a "positive void coefficient"—the speed of the chain reaction within the core would increase during a loss of cooling water accident--engineers deemed a serious loss of cooling accident virtually impossible and expressed confidence in the RBMK.[15]

By the mid-1970s the first commercial production reactors (about 1000 MWe) had started up.[16] The USSR had large reserves of oil and natural gas; however, those resources were generally reserved for export in exchange for the hard currencies of the West.[17] Output of the easily accessible coal deposits had dwindled and the main center of coal production was shifting to Siberia and the Russian Far East.[18] It would take time to build the infrastructure to access the coal fields, establish the towns for the workers and their families, and erect the transport system to move the coal to the power stations in the western parts of the USSR (or build new power stations nearer the coal resources). Nuclear power became the preferred option for electricity generation. By 1980, nine nuclear plants were in operation across the USSR, with 24 more under construction.[19]

The 11th Five Year Plan (1981 – 1985) called for a 300% increase in output and the proportion of nuclear energy in the electric supply to about 14% of the total.[20] At the same time, thermal electricity (from coal- and natural gas-fired plants) would decline to about 71%. For Ukraine alone, the aim was to complete two more reactors at Chernobyl and a second unit at the Rovno facility, and to finish the South Ukrainian Station.[21] Three more nuclear power plants were also to be added in Zaporizhzhia, Crimea, and Kmelnytsky.[22] While the nation-wide output from nuclear did double during the period, in part by raising the capacity factor at existing plants and in part by bringing nine new facilities on line, the goal of a 300% increase was not achieved.[23] The Minister for Power and Electrification lost his job.

The 12th Five Year Plan (1986 – 1990) proved only a little less ambitious. With a focus on expanding nuclear generation at existing sites rather than building new ones, the government outlined a plan that included 390 billion kWh of nuclear by the end of the decade, up from 170 billion kWh in 1985.[24] According to then First Deputy Chief of the USSR State Planning Committee, L. Bibin, "In electrical energy, one of the key directions of scientific-technical progress is to raise the proportion of electricity generated at atomic energy stations."[25] Speed in connecting the plants to the electric grid was of prime importance to meet the deadlines of this five year plan.

The very close connection between the government, the academic community, and implementation of nuclear technology to generate electricity--"progress"—that existed in 1985 in the Soviet Union is depicted in Figure 6.1 below. The red dashed ellipsis in Figure 6.1 underscores the emphasis placed on expanding nuclear power for electrical generation by the Soviet State, despite its costs and the uncertainties associated with the technology, rather than investing in the more familiar technology to exploit the coal deposits in eastern Russia. Some of the repercussions of those decisions will be discussed in the next section.

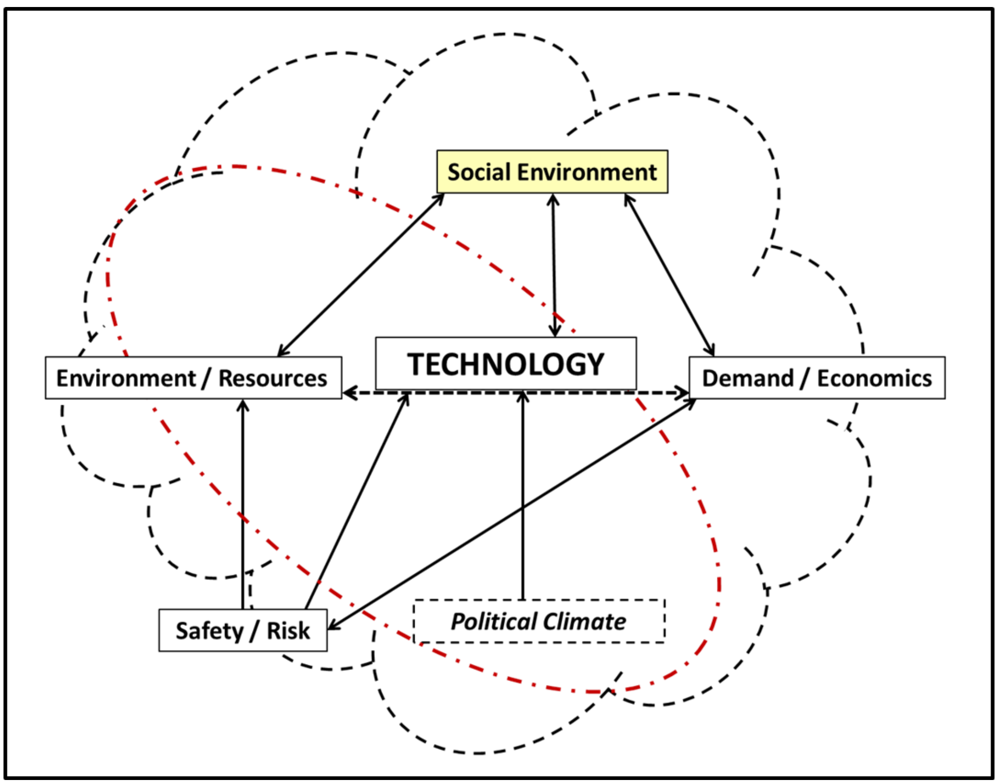

Figure 6.1   The Socio-Political Ecology of Nuclear Technology, pre-1986

6.2 Commercial Nuclear Power in Ukraine

Unlike much of Ukraine, blessed with fertile, dark, soil, the north-central part of the region, near the junction of the Pripyat and Uzh Rivers, had never been very productive. Its sandy, peaty soil and marshlands made agriculture difficult.[26] Staple crops included potatoes and flax, not the wheat, corn, or sunflowers grown elsewhere in the former Soviet Socialist Republic.[27] As a result, the area also was sparsely populated. The absence of large villages (and being 25 – 40 km from any large city), the abundance of water, and the proximity of Ukraine to other Soviet Bloc countries (Hungary, Rumania, Bulgaria, Poland, Czechoslovakia) made it an ideal location for erecting a nuclear power plant.[28]

Mention of two RBMK reactors at the "Chernobyl Atomic Regional Electric Power Station" appeared in Communist Party documents as early as 1967.[29] In March 1970, the Soviet Minister of Energy laid the ceremonial cornerstone for what was then known as the Chernobyl Nuclear Power Plant.[30] Construction of the village of Pripyat began that same year. Pripyat was expected to house 150,000 – 200,000 workers and their families when completed. It would provide recreation, schools, above-standard housing, parks, health care facilities, and other amenities designed to lure prospective employees to the remote area of Ukraine. Even so, attracting skilled workers proved difficult, particularly given the competition from other nuclear power projects under construction across the Soviet Union.[31] As had occurred at Hanford decades earlier, many arrived at the site only to find no permanent housing and nothing to occupy their free time.[32] Drinking became the diversion of choice. Workers showed up late for work and a lack of discipline among workers affected the quality and pace of the work. Eventually, project managers brought in "shock workers"—construction teams adept at completing projects in a short amount of time—to speed up completion.[33]

But it was not just the workers who were problematic. Since the Chernobyl facility was one of the first commercial sized RBMK reactors constructed, as at Hanford, the approach to construction was essentially one of “trial and error.”[34] The workers on site had to discover the answers to problems they faced and had to devise ways of making things work. Few technological standards existed at the time. Additionally, workers encountered shortages of tools, shortages of instruments, and material shortages.

> Equally helpful to the builders of the Chornobyl atomic energy station last year were the suppliers of metal structure, who undersupplied by 2,359 tonnes [2600 tons], and what was delivered was largely faulty. This includes 326 tonnes [360 tons] of fissure sealant for the nuclear fuel waste depository, which arrived in a defective state from the Volzhskii metalworks. The same plant was partially responsible for defects in the manufacture of girders for the machine hall.
>
> Liubov Kovalevska, *Literaturna Ukraina, March 1986* [35]

When supplies did not arrive, or were found to be defective, work stopped. Then word would come from the Minister of Power and Electrification to move up the schedule for completion—to save on coal.

According to one Western observer who visited a Soviet RBMK plant in May of 1986, it looked “shoddy, a ‘tin shed,’ poorly constructed, and with what appeared to be an inadequate concrete shield over the top of the reactor, through which steam was being emitted.”[36] The RBMK had no containment structure protecting the core (or the workers and the public) in case of a loss of coolant accident. Reassured by the reactor designers, Soviet authorities believed such an accident to be impossible and unimaginable. In addition, the reactor had no sprinkler system to protect against fire, and no way to control against a hydrogen explosion.[37] The RBMK did possess a basin of water beneath the reactor core that could be used in case of an emergency, and could withstand a plane crashing into its roof.[38]

The first of the six planned Chernobyl reactors came on line in 1977; the second in 1978. Units three and four were completed in 1983.[39] Construction on units five and six was under way. In a push to meet an aggressive completion schedule, the usual six months of safety checks for the fourth reactor had been shortened to four.[40] In some cases, parts failed those checks and were replaced, but not re-evaluated. In fact, the trial of six senior administrators of the Chernobyl Nuclear Power Plant of July and August 1987, revealed that

> [o]n 31 December 1983, despite the fact that the necessary tests had not been conducted on reactor No. 4, [former director of the Chernobyl Nuclear Power Plant] Bryukhanov signed an act accepting into operation the launching complex of the reactor and certifying that it had been completed. Aiming to bring the safety systems into working order, tests were conducted on the turbogenerator between 1982 and 1985. These tests were unsuccessful and remained incomplete.[41]

The turbogenerator was considered a major safety component of the RBMK reactor system.[42] If the reactor ever shut down, the energy from the turbogenerator would maintain the proper voltage in the electrical system to keep the cooling water pumps operating until reactor operators could turn on backup diesel generators. That cooling water is critical for keeping the reactor from overheating. Even so, without successful tests of the turbogenerator, at the beginning of March 1984, an article in *Pravda Ukrainy* reported that Chernobyl Unit 4 would commence commercial operation two months ahead of schedule.[43] This assured thousands of workers, engineers, Ministers and Committee members they would receive the titles ("honored energy worker"), bonuses, and awards they coveted.[44]

Testing of the turbogenerator in Unit 4 was again scheduled for the night of April 25, 1986 as the unit was being taken off-line for routine maintenance. It remained to be seen if the turbogenerator would continue to provide enough power to operate the main cooling water pumps between the time the reactor shut down and back-up generators came on line.[45] Power reduction began as planned. Output had reached about 50% when the regional load dispatcher notified those at Unit 4 that the grid needed the electricity it supplied; the planned tests had to be delayed until the wee hours of the next morning.[46]

Much has been written about the events of April 26, 1986, who did what when and why.[47] Was it human error, construction defects, equipment failure, or design flaws that led to the catastrophe? The emergency core cooling system had been switched off to enable the test to proceed. As the tests got under way the power level in the reactor became unstable. Rather than abort the tests, the deputy chief engineer, Anatoly Dyatlov, insisted that the operators stabilize the reactor. Power output fell to a mere 30 MW. By withdrawing control rods, operators on duty finally stabilized the reactor at 200 MW, still well below the 700 – 1000 MW called for by the test protocol.[48] Instead of the minimum of 15 rods in the core as called for by operating procedures, only 6 – 8 remained in the core. To prepare for the test, the operators increased the flow of cooling water to the core.[49] The reactor became increasingly unstable.

The cooling water circulation pumps powered by the turbogenerator began to slow as the power to the generator decreased. The temperature of the water itself began to rise, generating steam; the fuel elements in the reactor began to overheat and fuel channels ruptured. Power in the reactor rose dramatically.[50] The reactor operators tried to initiate an emergency shutdown, but it was too late. The emergency control rods, housed in the upper part of the reactor core, moved part way down, then stopped. They did not, and could not, move further.[51] Within seconds a powerful steam explosion rocked Unit 4, lifting the 1000 ton plate above the reactor, rupturing pipes and more fuel channels. Another explosion followed (possibly a hydrogen explosion),[52] sending reactor fuel, graphite, and structural debris into the air, onto the roof of adjoining Unit 3, and onto the grounds surrounding the buildings. Almost 20 million curies of radioactive materials and several million curies of inert radioactive gases erupted into the atmosphere.[53] Fires broke out. The reactor core lay exposed.

The Deputy Chief Engineer Dyatlov continued to believe that the reactor remained intact, despite reports of damage from his colleagues and the obvious signs of radiation exposure on the part of many reactor operators—vomiting and rapid darkening of the skin known as a “nuclear tan.”[54] Within about five minutes of receiving word, firefighting units from the local station were on site, trying to douse the flames of 30 – 40 fires. Firefighters from Pripyat quickly followed.[55] According to the wife of one firefighter,

> Everything was radiant. The whole sky. A tall flame. And smoke. The heat was awful . . .
>
> The smoke was from the burning bitumen, which had covered the roof. He said later it was like walking on tar. They tried to beat down the flames. They kicked at the burning graphite with their feet . . . They weren’t wearing their canvas gear. They went off just as they were, in their shirt sleeves. No one told them. They had been called for a fire, that was it.
>
> Lyudmilla Ignatenko, wife of deceased fireman[56]

One group of firefighters went to great lengths to extinguish the fires on the roof of Unit 3, which was still operating, and the turbine hall building that joined Units 3 and 4. Others tackled the fires in Unit 4, not knowing that the core had been exposed.[57] Surprisingly, there was no equipment on site at the time to measure radiation, no breathing apparatus to protect them from breathing toxic gases.[58] Pumping water into the giant opening only spread the radiation further throughout the maze of shattered pipes and passageways. The visible flames were put out by 5:00 am, but the battle had just begun.

The people of Pripyat, only 3 km away, could see the activity at the plant. Over a hundred people had already been admitted to the Pripyat hospital as a result of the events of the night.[59] Policemen walked the streets. Still, many husbands and fathers scurried off to work that Saturday. Life in town went on as usual. Children walked to school. Mothers with babies met in the town squares. Clothes hung out to dry. Jurnalist Lyubov' Kovalevskaya awoke that Saturday morning to find

> [a]ll roads were covered in water and some white liquid. Everything was white, foamy, all the curbs . . . I walked further and saw a policeman here, another there. I had never seen so many policemen in the town . . . It was very hot. People were going to the beach, or sitting by the stream, next to the cooling reservoir. That's an artificial water reservoir next to the nuclear power station . . . We knew nothing all day. Nobody said anything. Well, they said there was a fire. But about radiation, that radioactivity was escaping, there was not a word.[60]

As men on the ground at Chernobyl struggled to put out fires, local officials and nuclear experts had finally come to understand the real situation unfolding before them. The reactor core was not intact and radiation levels continued to increase with every passing minute. By 10 am on April 27th, helicopters began dropping bags of sand into the reactor, then clay, boron, lead, and dolomite.[61] Experts expected the sand and clay to quench the fire, depriving it of oxygen. Boron, a neutron absorber, has been used as a last ditch reactor shut down back up system since the construction of the B reactor at Hanford.[62] Helicopters dropped in loads of lead and dolomite as heat absorbers.

> From above, from the helicopter, when I was flying near the reactor, I could see roes and wild boars. They were thin and sleepy, like they were moving in slow motion. They were eating the grass that grew there, and they didn't understand, they didn't understand that they should leave.
>
> Should I go or not go? Should I fly or not fly? I was a Communist—how could I not go?
>
> From above I saw a ruined building, a field of debris—and then an enormous number of little human shapes. There was a crane there, from East Germany, but it wasn't working—it made it to the reactor then died. The robots died . . . And the Japanese robots—all their wiring was destroyed by the radiation, apparently. But there were soldiers in their rubber suits, their rubber gloves, running around . . .
>
> Major Oleg Pavlov, Helicopter Pilot[63]

That same day, local officials made the decision to evacuate the people from Pripyat and the villages surrounding the Chernobyl Nuclear Power Plant. Twelve hundred busses arrived from Kiev to carry the 43,000 – 45,000 residents, their identity papers, and three days' worth of belongings and food, to provisional, but safer, lodgings.

> For the attention of the residents of Pripyat! The City Council informs you that due to the accident at Chernobyl Power Station in the city of Pripyat the radioactive conditions in the vicinity are deteriorating. The Communist Party, its officials and the armed forces are taking necessary steps to combat this. Nevertheless, with the view to keep

> people as safe and healthy as possible, the children being top priority, we need to temporarily evacuate the citizens in the nearest towns of Kiev Oblast. For these reasons, starting from April 27, 1986 2 pm each apartment block will be able to have a bus at its disposal, supervised by the police and the city officials.[64]

Residents were never allowed to return.

Prevailing winds carried the plume from the explosions in a northwestern direction. Radiation detectors picked up radioactivity on workers *entering* the Forsmark Nuclear Power Plant north of Stockholm, Sweden on April 27.[65] Further analysis by Swedish scientists determined the radiation release had been occurring for some time and was coming from a reactor located somewhere in the western Soviet Union.[66] Other readings were soon reported on the shores of the Baltic Sea, southwest of Stockholm.[67] The impact of the radiation releases on Europe as shown in Figure 6.2 below, where Plume A refers to an air mass that originated at Chernobyl April 26, Plume B on April 27 - April 28, and Plume C on April 29 – April 30. The numbers in the various European countries correspond to the dates on which radioactivity was initially detected there: 2. April 27, 3. April 28, 4. April 29, 5. April 30, 6. May 1, and 7. May 2, and 8. May 3.

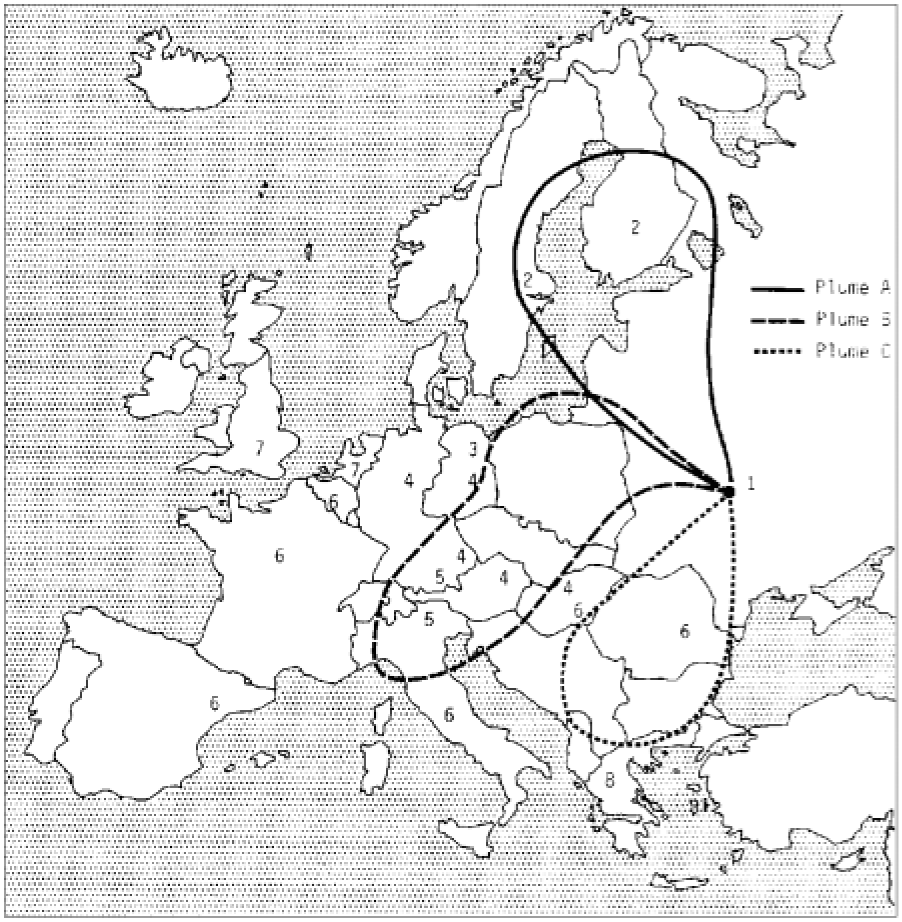

Figure 6.2 Fallout from Chernobyl[68]

Finally, on April 28, after Swedish officials demanded information, the Council of Ministers in Moscow announced an accident at the Chernobyl Plant and that measures were being taken to handle the problem.[69] Aid was being given to those in need. Soviet officials released few other details.

Work continued to try to bring the stricken Unit 4 under control. Mechanical robots quickly malfunctioned due to the extremely high levels of radiation.[70] They were replaced by "bio-robots":[71] Hundreds of thousands of civilians and soldiers ("liquidators") brought in from all over the Soviet Union to help with the project. The sand and clay poured into the reactor trapped the heat that continued to build up inside, resulting in a flurry of new activities. The pool below the reactor had to be drained to prevent another steam explosion. Liquidators then filled the empty spaces with liquid nitrogen that had been shipped in from all over Ukraine.[72] (Nitrogen becomes a liquid at about -196 ^{o}C.) As coal miners tunneled under the reactor to build a lead-lined concrete dish under the core to cool it down and to prevent the molten material reaching the groundwater below,[73] other workers started injecting liquid nitrogen into every possible hole or gap around Unit 4.[74]

On May 3, scientists noted a change in the composition of the radionuclides being released. The amount of iodine and cesium decreased but the amount of zirconium and ruthenium increased. The latter two isotopes had extremely high melting points (1,852 ^{o}C and 2,250 ^{o}C respectively), indicating another meltdown of the core had occurred.[75] However, just as suddenly, on May 5, the releases of radiation and the temperature dropped.[76]

While many toiled at the reactor, other liquidators at Chernobyl focused on the areas around the plant. Radiation experts from the Mayak Nuclear Plant--site of the Kyshtym disaster which released about 20 million curies of radioactive waste into the atmosphere on September 29, 1957—traveled throughout the evacuated area to map out radiation levels and identify what later became the Zone of Alienation or "Exclusion Zone" (authorities initially drew a 30 km circle, which did not reflect the actual pattern of radiation fallout, as shown in Figure 6.3 below).[77] Other liquidators received assignments to wash down dusty roads, destroy homes that had been abandoned, shoot any animals that crossed their paths, bury vehicles and farm equipment, or cut down and bury forests that had turned red from radiation exposure. As time went on, new liquidators replaced the old to guard the exclusion zone and make sure no one came back to scavenge what evacuees had left behind.

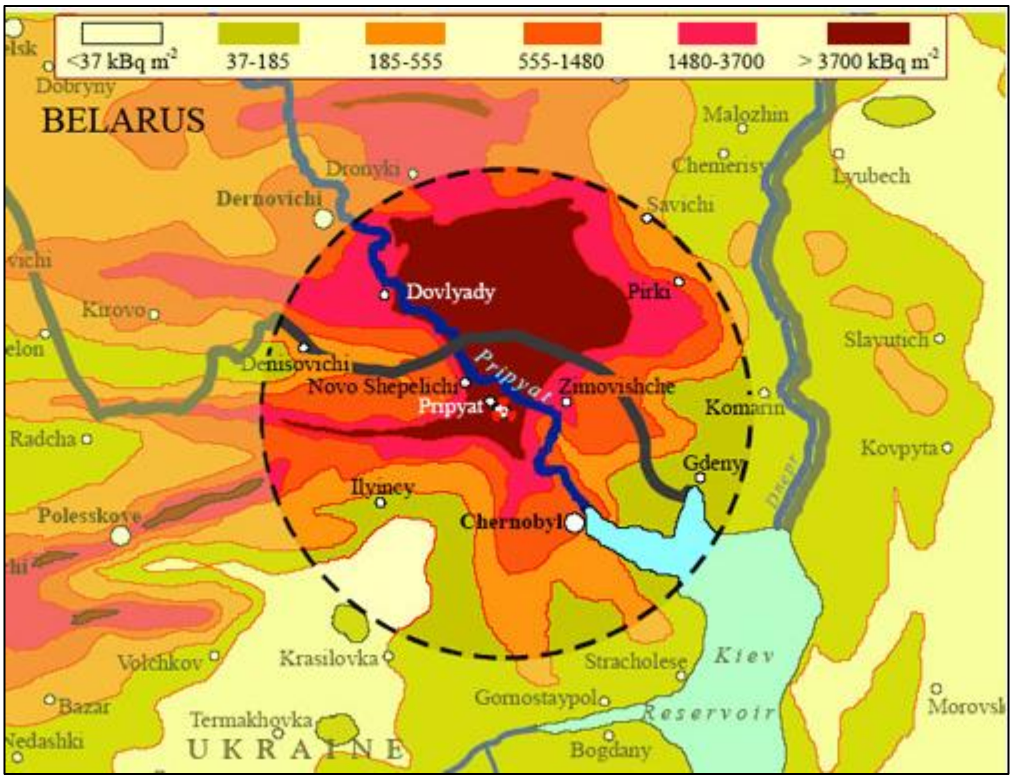

Figure 6.3 Fallout from Chernobyl and the Location of the Initial 30 km Exclusion Zone[78]

By the second week of May, Soviet authorities decided to enclose the damaged reactor in a concrete shell.[79] Scientists were well aware that the reactor would need to be buried for hundreds or thousands of years to prevent the release of the remaining radioactive materials into the environment. The Russian Scientific Research Institute of Integrated Energy Technology provided the final design for the containment structure.[80] In that design, the damaged reactor building forms the east wall of the structure; the west wall is composed of concrete propped up by a series of buttresses. Steel roof panels resting at an angle of 15 degrees from vertical form the south wall, and a combination of concrete and parts of the damaged reactor building make up the north wall. Massive beams were fashioned to hold up the roof—a combination of steel pipes and steel panels.

Between May and November of 1986, another group of liquidators erected the metal and concrete walls to contain the damaged reactor and the radioactive debris from the damaged building and the clean-up operations.[81] The high levels of radiation at the site precluded the use of ordinary construction techniques. Concreting was carried out by remote control and some welds between steel plates and beams were left unfinished.[82] Although the structure, nicknamed the "Sarcophagus," did reduce the radiation emissions by a factor of 10 – 20, moisture trickled in through vents and other openings in the structure.[83] Heat and radiation from the inside continued to threaten the structural integrity of the Sarcophagus. By 2007, scaffolding was erected on the exterior to brace the walls of the Sarcophagus until a replacement structure could be put in place (See Figure 6.4). A section of the roof of the turbine hall, next to the reactor, collapsed in 2013, releasing additional radiation into the atmosphere.[84]

Figure 6.4 Unit 4, Summer 2007, Image by the Author

As early as 1995, the Group of Seven (G7) nations (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) agreed to finance a replacement for the Sarcophagus. The financial backing now comes from more than 40 nations.[85] The structure being constructed resembles a giant arch, roughly 250 feet long and 800 feet wide, and is expected to last for 100 years.[86] The new arch has both rust-proofing and dehumidifiers built into the design. Sometime in 2017 it will slide along Teflon pads over the remains of the Sarcophagus and its ends will be sealed. The cost estimate at the time of this writing: $1.7 billion.[87]

6.3 The Aftermath of Chernobyl

The impact of the Chernobyl catastrophe on the environment has been debated since 1986. Some effects are still visible: A forest of pygmy pines named the "Red Forest" grows atop a waste dump. The trees that originally grew there stood in the trajectory of radioactive debris and turned red before dying. Liquidators buried them and other waste under four feet of sand and a layer of liquid polymer.[88] Even so, trees that have sprouted up afterwards continue to be very radioactive, lack a central trunk, and resemble bushes more than trees.[89] Trees throughout the region had absorbed radionuclides that had made their way into the ground. Because the radionuclides remained in the circulation layers and not the bark, as long as the trees have remained standing and growing, the trees have provided a good way to "fix" those toxic materials and prevent them from dispersing. However, fires continue to be a big concern—either forest and peat fires, like one that broke out in August 1992, or the use of wood for cooking or heating—since they release the radioactive particles trapped in the wood into the air and thus available for further contamination.[90]

Forty percent of winter wheat crop sown before the explosions at the reactor exhibited abnormalities when it emerged in 1986 – 1987.[91] Yarrow, millet, cress, and other plants within 5 km of the plant showed unusual branched stems, abnormal coloration, and changes in the size of their leaves and flowers.[92]

Mushrooms, nuts, berries, and other fruits concentrate radioactivity. People in Ukraine and Europe used to picking those items, making jams and pies had to be restricted from partaking in those activities.[93]

Farm animals left behind consumed large amounts of contaminated vegetation and breathed toxic air. Those found in areas of high radiation had depressed thyroids (a result of radioactive iodine), depressed immune responses, and cardiac disorders.[94]

Offspring of cattle and sheep were smaller than normal. Stories about mutations of other animals in the zone abound. Some scientists respond by indicating that malformed wild animals would not survive.[95] Others downplay the existence of any such deformities. Most information about wild animals in the exclusion zone relies on observational data, not statistical experiments, and most studies have focused on deer and boar which tend to roam outside the zone and get hunted for food. The animals tend to look normal although their meat far exceeds safe levels of radiation.[96] A report by the Chernobyl Forum, a consortium of 100 scientists convened under the auspices of the International Atomic Energy Agency in 2003 to reach a scientific consensus about the impact of the Chernobyl accident, concluded,

> Genetic effects of radiation, in both somatic and germ cells, were observed in plants and animals in the CEZ [Chernobyl Exclusion Zone] during the first few years after the accident. Both in the CEZ and beyond, different cytogenetic anomalies attributable to radiation continue to be reported from experimental studies performed on plants and animals. Whether the observed cytogenetic anomalies have any detrimental biological significance is not known.[97]

More recent work by Mousseau and Møller has examined the impacts of radiation on bird species, finding that mutation rates have increased by up to a factor of 20.[98] Most species of birds are found in areas with low radiation levels; rare species appear only in areas with low radiation levels. In the case of raptors, the low adult survival rates and fecundity has been offset by in-migration of other birds.[99] Butterflies, bees, spiders, grasshoppers, and other invertebrates also showed decreased abundance as the level of radiation increases in the forests around the Chernobyl site.[100] The resulting lack of pollinators, decomposers, and food source for other species, may have large ripple effects for the local ecosystem.

The Chernobyl Forum did admit that a major impact of Chernobyl was the increased incidence of thyroid disease in children and young adults.[101] Radioactive iodine 131, iodine 132, and iodine 133 lodge in the thyroid. Because of their short half-lives, they decay rapidly and begin destroying the cells of that gland. Children tend to be particularly sensitive. Before the accident, thyroid cancer in the region was rare and found mainly in older people.[102] Physicians noted steep increases in thyroid cancer within 4 – 6 years after the explosions and fires; by the mid-1990s children in radiation-affected areas of Belarus exhibited cancer levels 100 times higher than normal.[103] In Ukraine, the number of thyroid cancer cases increased ten-fold over a period of ten years.[104] Iodine 131 contaminated the milk, drinking water, and other food. While many screenings of food suppliers did occur, people living at or below the poverty line could not afford to buy imported supplies and continued to eat off the land. In addition, officials never evacuated some contaminated areas. As might be expected, those whose diets depended mainly on wild game, berries, and mushrooms received the highest doses of radiation (including the dose to the thyroid).[105]

Chernobyl's almost 600,000 liquidators received very high doses of radiation, monetary rewards, and medals commemorating their heroic service to the nation. Although the Soviet Union admitted to the deaths of two reactor personnel and 28 firefighters immediately after the explosions at Chernobyl, there has been no admission of increases in cancers or early deaths among the liquidators attributed to their work at the site. First, many Soviet citizens had poor diets, a habit of drinking vodka to excess, and smoking, all of which could contribute to heart disease and cancer. Second, officials on site kept no accurate records of the doses received by each of the liquidators during their tour of duty at Chernobyl.[106] Third, after leaving

Chernobyl, the liquidators dispersed across the country. There was no central registry. Yet many liquidators have died at young ages, committed suicide, suffer from cardio-vascular diseases or cerebrovascular diseases, or remain invalids.[107] The Kharkiv, Ukraine regional and municipal councils of the Chernobyl Union, an organization created after 1990 to assist victims of the Chernobyl disaster, noted that 300 liquidators residing there died between 1986 and 1990. Of those, 47% committed suicide or drank themselves to death.[108]

> They came for my father at night. I didn't hear how he got packed, I was asleep. In the morning I saw my mother was crying. She said, "Papa's in Chernobyl now."
>
> He came back and started going to the factory again . . . At school I bragged to everyone that my father just came back from Chernobyl, that he was a liquidator, and the liquidators were the ones who helped clean up after the accident. They were heroes. All the boys were jealous.
>
> A year later he got sick . . .
>
> They worked pretty close to the reactor. It was quiet and peaceful and pretty, he said. They took off the topsoil contaminated by cesium and strontium, and they washed the roofs. They next day everything would be "clicking" on the dosimeters again.
>
> "In parting they shook our hands and gave us certificates of gratitude for our self-sacrifice." . . . Mom and I are alone now.
>
> Olya Zvonak, 10[109]

6.4 The Socio-Political Ecology of the Chernobyl Nuclear Accident

On May 14, 1986, Mikhail Gorbachev finally addressed his anxious nation about the events unfolding at the Chernobyl Nuclear Power Plant.

> Good evening, comrades.

> As you all know, a misfortune has befallen us -- the accident at the Chernobyl nuclear power plant. It has painfully affected Soviet people and caused the anxiety of the international public. For the first time ever we encountered in reality such a sinister force as nuclear energy that has escaped control. So what did happen? As specialists report, the reactor's capacity suddenly increased during a scheduled shutdown of the fourth unit. The considerable emission of steam and subsequent reaction resulted in the formation of hydrogen, its explosion, damage to the reactor and the associated radioactive release.[110]

Gorbachev criticized the response of the Western press, their exaggerated stories of mass casualties and destruction of Ukraine. He then he called for an era of more transparent communications and cooperation:

> [W]e deem it necessary to declare for a serious deepening of cooperation in the framework of the International Atomic Energy Agency. What steps could be considered in this connection?
>
> First, creating an international regime of safe development of nuclear power on the basis of close cooperation of all nations dealing with nuclear power engineering. A system of prompt warning and supply of information in the event of accidents and faults at nuclear power stations, specificially (sic) when this is accompanied by the escape of radioactivity, should be established in the framework of this regime. Likewise it is necessary to adjust an international mechanism, both on a bilateral and multilateral basis, for the speediest rendering of mutual assistance when dangerous situations emerge.[111]

As he sought to be more open with his Soviet public through glasnost, Gorbachev also sought to have a more open dialogue with other nations. The political climate in the Soviet Union had begun to change.

Although the government and academicians dominated the early years of the development of nuclear technology in the Soviet Union, it has become clear that other elements of the Socio-Political Ecology Framework have also become important for understanding the Chernobyl Nuclear catastrophe, as outlined in Figure 6.5 below.

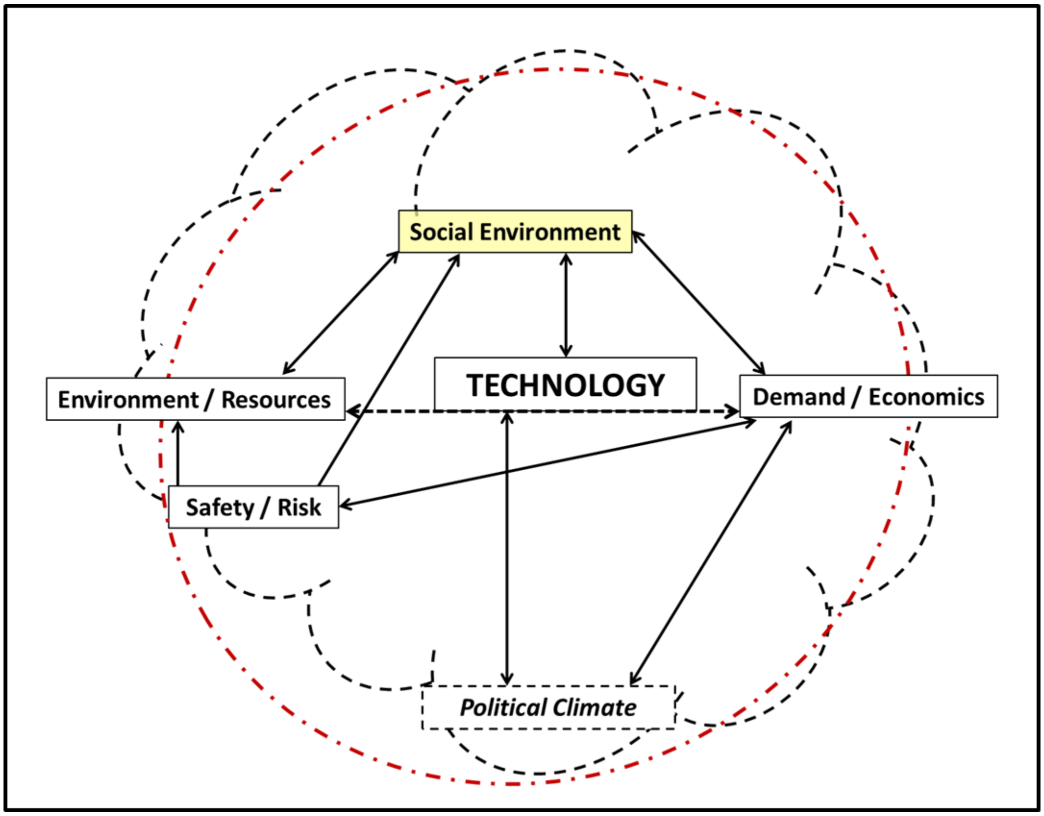

Figure 6.5 The Socio-Political Ecology, post-Chernobyl Accident

For example, as mentioned in the case of the Red Forest earlier, the accident affected the natural environment as radioactive isotopes from the explosion and fires made their way through the air, water, and soil, plant and animal systems. Reindeer in the northern regions of Norway, Sweden, and Finland fed on lichen that absorbed and concentrated cesium 137.[112] The contaminated meat had to be destroyed.[113] Likewise, rain containing cesium 137, iodine 131, and strontium 90 fell onto the peaty soils of the uplands of England, Scotland, and Wales and made their way into the meat of sheep grazing on the grasses that grew there.[114] For decades, only animals testing below the Food Standards Agency limits for radiation could be sold at market. Physical abnormalities did appear in fish exposed to cesium 137 and strontium 90 in rivers, lakes, and the Chernobyl Nuclear Power Plant cooling pond.[115] Those abnormalities were particularly prevalent for predatory fish and those residing in water bodies that did not flush on a regular basis, such as the cooling pond or Lake Kozhanovskoe in Russia. A 2014 study of birds residing in the Chernobyl Exclusion Zone discovered more males without sperm in areas with high levels of background radiation than in areas with lower levels of radiation.[116] When present, sperm quality (velocity and motility) decreased in areas of high levels of radiation.

Likewise, as demonstrated in Figure 6.6 below, everyone at the site, in Pripyat, in Ukraine, Belarus, Eastern and Western Europe, and the world faced the risks imposed on them by the radiation that erupted from the open chasm of Chernobyl's Unit 4 reactor.

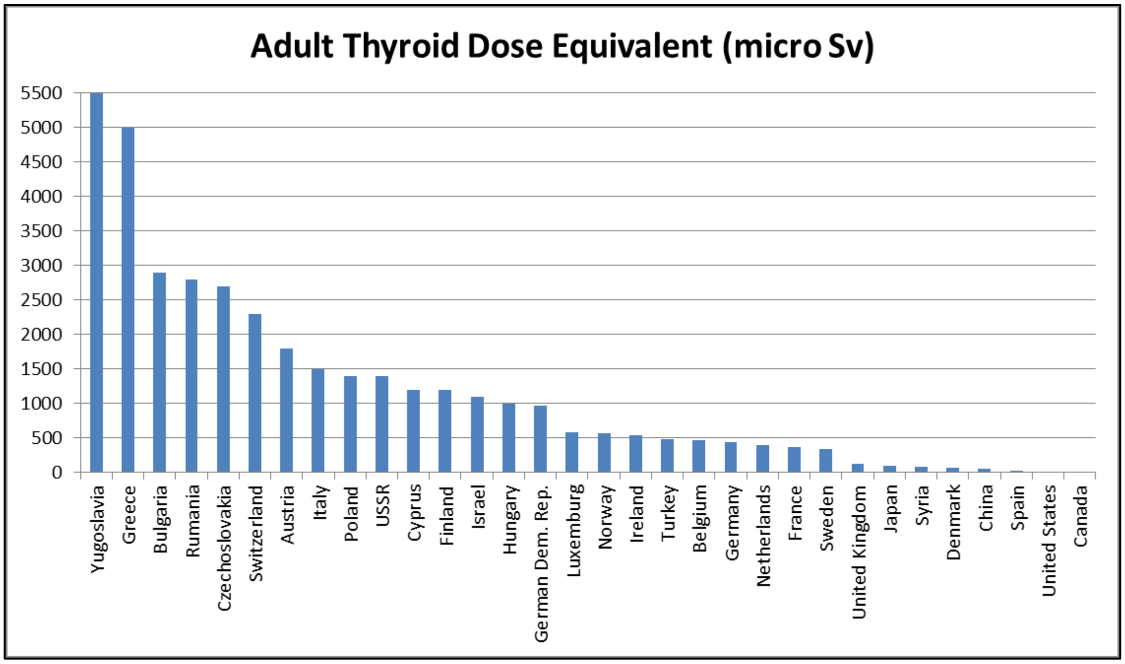

Figure 6.6 Country-wide First-Year Average Adult Thyroid Dose Equivalents from the Chernobyl Accident[117]

However, as has occurred at Hanford, except in the case of children, epidemiological studies cannot confirm that increases in cancers among any populations *directly* link to Chernobyl radiation releases.

Whereas Soviet officials once worried about the tradeoffs between coal, oil, natural gas, and nuclear power, their attention now turned to the need to clean-up and remediate the villages and farmlands affected by the catastrophe. They had to recruit and bring to the site hundreds of thousands of liquidators. At the same time, officials evacuated over 150,000 local residents from the exclusion zone. Finding transportation, new housing, food, and clothing for all of those people proved a daunting task. Treating the first firemen to respond to the call and other workers at the reactor who faced the agony of radiation poisoning also challenged the Soviet medical system. The Social Environment became a critical factor.

As at Hanford, the costs of the Chernobyl accident continue to rise. In 1988, the initial estimates of the direct and indirect costs of the catastrophe hovered around $15 billion.[118] Since then, estimates of the associated costs have risen to hundreds of billions of dollars. Not included in the original $15 billion were the ongoing health care costs of those exposed to radiation at the time of the catastrophe—the liquidators, the people of Pripyat and the villages under the radioactive clouds, the children who drank milk from the local cows and developed thyroid diseases in the ensuing years.[119] The costs of remediating and restoring agricultural lands or finding replacements sources for agricultural products and other foodstuffs also must be taken into account. Belarus canceled its own plans for nuclear power plant construction in 1986 and has relied on expensive natural gas imports from Russia to generate electricity in the intervening years.[120] A fire resulted in the closure of Chernobyl Unit 2 in 1991. Unit 1 shut down in 1997 and, under pressure from the international community, Unit 3 finally ceased operations in 2000.[121] The closure of the facility left Ukraine with energy shortages and, like Belarus, dependent on neighboring Russia for natural gas supplies for years. For the damaged Unit 4, the price of the new safe containment arch stood at about $2.5 billion in April, 2016.[122] There still remain the costs of disposing of other radioactive waste scattered around the exclusion zone and the spent fuel stored in the other reactors at the Chernobyl Nuclear Power Plant.[123] As at Hanford, the radionuclides from that unsecured waste continue to migrate through the soil toward the water table below.[124] The final price tag of the events that started on April 26, 1986 has yet to be tabulated. The Demand/Economics factor in the Socio-Political Ecology framework cannot be ignored.

6.5 Conclusion

Only Russia remains committed to the RBMK design, at least through 2034, as indicated in the timeline shown in Table 6.1 below. As those reactors shut their doors, those communities along with scientists and local governments will be left to deal with questions of how to handle the decommissioning of those reactors, safely disposing of the radioactive elements remaining in them, and determining what, if anything, can be done with the abandoned sites.

> I wish to draw your attention to the fact that in our state the public, and public opinion, have not been allowed to become involved in problems pertaining to the planning and siting of nuclear power stations. This will lead, and has in fact already led, to mistakes and grave complications, since the experts are unable, despite their good intentions, to take into account all economic, ecological, demographic, social, and other conditions and circumstances . . . All developed countries have long realized that public involvement in the solution of technical tasks is essential, and that both technical progress and the scientific and technical revolution thereby acquire a human dimension.
>
> Andrei Sakharov, Russian Nuclear Physicist, Nobel Laureate, in a letter to Comrade M. S. Gorbachev, Chairman of the Presidium of the Supreme Soviet of the USSR, 1988[125]

Table 6.1 An Overview of the History of Chernobyl and Soviet Nuclear Power

Phase	Month	Year	Event
Planning			
		1941	Klaus Fuchs begins passing British nuclear military research data and later Manhattan project data to NKVD to jumpstart Soviet nuclear program
	Aug	1942	Secret government order № 2352ss on organizing uranium-related activities signed
	Apr	1943	Instrumentation Laboratory No. 2 (currently known as Russian Research Center Kurchatov Institute) established within the Academy of Sciences
	Aug	1949	First nuclear charge successfully tested in Semipalatinsk, Kazakhstan
		1954	First nuclear power plant, 5 MWe Obninsk station went on line
	Sept	1957	Kyshtym disaster at Mayak Nuclear Complex released about 20 million curies into atmosphere
Construction			
	Mar	1970	Town of Pripyat founded at start of construction of Chernobyl nuclear power plants
		1970 - 1986	Soviets began construction on 47 VVER and RBMK units across Russia, Ukraine, and Lithuania
		1971	First VVER commercial reactor came on line at Novovoronezh, Russia
		1974-1982	Soviets built 10 commercial reactors in Soviet Bloc Countries (Armenia, Bulgaria, East Germany, and Slovakia)
Operation			
		1977	Chernobyl RBMK Unit 1 started production
	Sept	1982	Partial meltdown of the core of Chernobyl Unit 1
	Dec	1983	Chernobyl RBMK Unit 4 on line
	Apr 25	1986	Testing of Unit 4 Turbogenerator scheduled but delayed until the early hours of April 26
	Apr 26	1986	Explosion and fire in Unit 4 started; the beginning of the Chernobyl catastrophe
	Apr 27	1986	Helicopters started dropping sand, clay, boron, lead and dolomite on the destroyed reactor

Table 6.1 continued

Legacy			
	Apr 27	1986	Decision made to evacuate City of Pripyat
	Apr 28	1986	Under pressure from Swedish officials, the Council of Ministers in Moscow announced an accident at the Chernobyl Plant and measures were being taken to handle the problem
	May 2	1986	Exclusion zone expanded from 10 km to 30 km diameter circle, causing a 2nd evacuation
	May 5	1986	Second explosion of reactor and large scale radiation release occurred
	May 14	1986	General Secretary Mikhail Gorbachev made first public television address about the Chernobyl disaster
	May	1986	Decision made to enclose damaged reactor in concrete shell
	Nov	1986	Construction of Sarcophagus over Unit 4 completed
		1988	All new RBMK reactor construction projects suspended and cancelled
	Oct	1991	Fire in the turbine hall of Chernobyl Unit 2 prompts shutdown of that reactor
		1995	G7 countries agreed to fund replacement for the Sarcophagus
	Nov	1996	Chernobyl Unit 1 shut down
	Dec	2000	Pressure from the international community forced shutdown of Chernobyl Unit 3
		2004	Closure of Lithuania’s Ignalina RBMK reactor Unit 1
		2007	Scaffolding erected to brace walls of Sarcophagus from collapse
		2009	Closure of Lithuania’s Ignalina Unit 2
		2017	New containment structure to be slid over Sarcophagus and sealed
Looking ahead at other RBMK scheduled shutdowns in Russia			
		2019	Leningrad 1
		2021	Kursk 1 and Leningrad 2
		2024	Kursk 2
		2025	Leningrad 3

Table 6.1 continued

		2026	Leningrad 4
		2028	Smolensk 1
		2029	Kursk 3
		2030	Kursk 4 and Smolensk 2
		2034	Smolensk 3

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Chapter 7

CONTEXTUALIZING JAITAPUR

7.1 The Historical Context

At the opening of the first International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland in August, 1955, UN Secretary Dag Hammarskjold pronounced that the world had entered a new era, one in which

> man will have left his bewilderment and his fear behind and will begin to feel the elation of one of the greatest conquests made by his mind . . . I am sure that this Conference will demonstrate the many practical uses to which those discoveries could be put for curing some of our worst physical, social, and economic ills, for raising the standard of living, and for lifting mankind to a higher level of well-being.[1]

One of the Chairmen of that 1955 Conference was Dr. Homi Bhabha, founder of the nuclear program in India and key advocate for the use of nuclear technology to power India's economic development and provide energy security.[2] Dr. Bhabha, a Cambridge-trained nuclear physicist, had argued for the establishment of a nuclear program in India since his days as a student in the UK. In words similar to those used by Hammerskjold a decade later, he had urged in 1944 that

> [a]ny substantial rise in the standard of living in this region [India]—that can be sustained in the long term—will only be possible on the basis of very large imports of fuel or on the basis of atomic energy.[3]

With the help of industrialist Sir Dorabji Jamsetji Tata and the Tata Trust, Dr. Bhabha establish the Tata Institute of Fundamental Research in Bombay (now

Mumbai), where he gathered elite scientists of the time to research atomic science, mathematics, and science, and to create India's nuclear program.[4] He also hoped to develop generations of Indian researchers who could set the standards for quality science throughout the country.[5]

The Indian Independence Act took effect at the stroke of midnight on August 15, 1947. That same day, Jawaharlal Nehru was sworn in as the first Prime Minister of the re-emerging nation. For Nehru, transforming India from a poverty ridden nation of poorly educated people required rejecting the small and the local in favor of big economic development projects, modern science, and advanced technology, including nuclear technology.[6] He strongly believed that the application of science and scientific thinking would solve the problems of illiteracy and poor sanitation, hunger and poverty. According to Nehru, that path was "inevitable and unavoidable."[7] Indeed, "[t]he future belongs to science and to those who make friends with science."[8] These words echo the theoretical arguments of Ellul, Byrne and Hoffman, and the idea of a Technological Imperative discussed in greater detail in Appendix A. For India, they meant a government closely connected with the scientific elite, and one that tied economic development to the yet unproven nuclear development.

As mentioned in Chapter 1, by 1947, the United States, France, and Great Britain had established agencies to oversee research and development into the civilian and military uses of the enormous power of the atom. In a similar fashion, the India Parliament passed its Atomic Energy Act in 1948; it established the Atomic Energy Commission (Indian AEC) that same year with Dr. Bhabha as its Chairman.[9] The Commission would be responsible for establishing policies and programs for nuclear development, organizing research and development in the nuclear arena throughout

India, training Indian nuclear scientists, and undertaking an inventory of nuclear fuels in India and overseeing the extraction of those fuels. The Indian AEC reported directly to the Prime Minister, at the behest of Nehru.[10] The Indian Department of Atomic Energy (DAE) emerged in 1954, to oversee basic research as well as the development of nuclear power, and the application of nuclear technology to agriculture, medicine, and industry.[11] The DAE would also carry out the policies established by the Indian AEC.[12]

The legislation that created the Indian Atomic Energy Commission and Department of Atomic Energy made nuclear technology the responsibility of the Indian state.[13] It also allowed those organizations to operate by rules they set and under veils of secrecy that prevented other nations from taking advantage of the discoveries before India had the opportunity to capitalize on them.[14] In addition, according to Dr. Manu Mathai,

> While publicly available information about the details regarding atomic energy [was] scarce, what [was] widely disseminated [was] an ideology of "progress" and "development" that [was] founded on the provision of abundant energy by the application of "advanced" science and technology. The public image of nuclear energy [had] been crafted in alignment with this narrative and found voice in influential opinions of both Nehru and Bhabha . . .[15]

While espousing nuclear technology as a critical source of electricity for the growing nation, Nehru did not rule out using the technology for military purposes. Because of the strict rules of secrecy imposed on the nuclear industry in India, any applications developed for the peaceful uses of the atom might also be applied to weapons development, and vice versa, without detection by outside groups. Furthermore, Nehru and the Indian government refused to participate in international initiatives to control the use and distribution of nuclear fuels, especially plutonium. A research and development center was erected in Trombay, Mumbai to develop equipment, and test and reprocess spent fuels. While reprocessing fuels was part of the three stage program set forth by Bhabha, the knowledge gained at that facility also gave India the ability to make atomic weapons.[16]

The three stage nuclear program formulated by Bhabha acknowledged India's lack of extensive domestic uranium reserves and focused instead to capitalize on the nation's known thorium supplies.[17] The first stage involves the construction of natural uranium-fueled thermal nuclear power reactors to generate the electricity needed for economic and social development. Reprocessing the spent fuel from those reactors would allow the recovery of valuable plutonium 239. That reduces the amount of waste from the first stage of the program and provides a fuel element for the second stage of the program. Stage two in the nuclear program requires the use of fast breeder reactors. The fuel for these reactors consists of a combination of uranium and plutonium. Technically, the fast breeder reactors should produce electricity and as much plutonium as they consume. Eventually, only plutonium will be used in the fast breeder reactors to preserve the uranium supplies.[18] The third and final stage of the program will rely on another type of fast breeder reactors fueled by plutonium plus uranium 233 obtained from the transmutation of the abundant thorium supplies.[19] Theoretically, India's future nuclear program will be fueled only by its natural occurring thorium.

Many years later, Dr. H. N. Sethna, former Secretary to the Government, Department of Atomic Energy, hailed the three stage nuclear program as promoting self-reliance and self-sufficiency in India.[20] The program supported a partnership between the nuclear industry and local research and development programs, necessitated the training of Indians scientists and engineers, would foster the creation of indigenous technologies and designs, and would lead to the creation of a manufacturing sector to support the nuclear industry. Self-reliance in this sense also meant reduced dependence on imports. It meant increased demand for Indian materials and Indian personnel.[21] After almost a century of British rule in India, the idea that the nation would be able to take into account "our own requirements and priorities and not [be] accountable to the whims and fancies of others" had great appeal.[22]

In 1958, the government refashioned the AEC with "full executive and financial powers."[23] The Secretary of the DAE became Chairman of the AEC. In 1962, the Indian Parliament revised the Atomic Energy Act, tightening the secrecy for the industry even further.[24] The Act restricted the publication of any information relating to:

1. The location, quality and quantity of prescribed substances and transactions for their acquisition, whether by purchase or otherwise or disposal, whether by sale or otherwise

2. The processing of prescribed substances and the extraction or production of fissile materials from them

3. The theory, design, construction and operation of plants for the treatment and production of any of the prescribed substances and for the separation of isotopes

4. The theory, design, construction and operation of nuclear reactors

5. Research and technological work on materials and processes involved in or derived from items [related to atomic energy or radioactive substances][25]

In addition,

> The Central Government may by order restrict the disclosure of information, whether contained in a document, drawing, photograph, plan, model or in any other form whatsoever, which relates to, represents or illustrates:
>
> 1. An existing or proposed plant used or proposed to be used for the purpose of producing, developing or using atomic energy, or
>
> 2. The purpose or method of operation of any such existing or proposed plant, or
>
> 3. Any process operated or proposed to be operated in any such existing or proposed plant[26]

In essence, the government maintained the right to completely restrict access to any information about nuclear technology in India.

Despite claims of self-reliance and indigeneity, outside assistance was vital to success in the early years. Sir John Cockcroft, a friend of Dr. Bhabha's from Cambridge, has been credited with providing the design for the 1 MW Apsara swimming pool-style research reactor.[27] The 40 MW Canadian-Indian Reactor, with heavy water supplied by the United States (thus dubbed CIRUS), began operation in 1960.[28] Neither research reactor produced electricity, but CIRUS did provide Indian engineers and scientists with knowledge critical for understanding the heavy water reactors built later across India.[29]

Work on India's first thermal nuclear power plant began in 1964 at Tarapur, Maharashtra: two boiling water reactors supplied under a turn-key contract from General Electric, with supplemental work done by Bechtel.[30] Both units use natural uranium as a fuel. Originally rated at 210 MWe each, the 160 MW reactors began supplying power to the electric grid in 1969.[31] Contracts also had been signed in the mid-1960s to build two Canadian "CANDU" heavy water reactors (using deuterium rather than hydrogen in the water molecule) at Rawatbhata in Rajasthan. Over 100 Canadian consultants journeyed to India to help out with the project.[32] The first reactor began operations in 1973. The Canadians abandoned the project before the completion of the second reactor when India detonated its first atomic bomb under the deserts of Rajasthan in May of 1974.[33]

In fact, in response to the Indian weapons tests, the Canadians froze all assistance to India, terminated their nuclear cooperation, and cut off the supply of the remaining components of the unfinished reactor.[34] As part of what came to be known as the Nuclear Suppliers Group Guidelines, Parties to the Nuclear Non-Proliferation Treaty (which had taken effect in 1970) agreed to refrain from shipping to India:

1. Nuclear material: Source material or fissionable material;
2. Reactors and equipment: Reactor fuel charging and discharging machines, control rods, pressure tubes, coolant pumps;
3. Non-nuclear materials for reactors such as deuterium for heavy water or nuclear grade graphite;
4. Plants or equipment for the reprocessing of irradiated fuel elements;
5. Plants for the fabrication of fuel elements;
6. Equipment designed or prepared for the separation of isotopes of uranium.[35]

The Nuclear Suppliers Group later amended the list to include any dual-use goods, equipment, materials, machine tools, and other non-nuclear items that can be used in weapons manufacture, or make a contribution to a "nuclear explosive activity."[36] In addition, the United States responded to the weapons test by withdrawing from its obligations to supply fuel for the Tarapur reactors and prohibited

GE from exporting spare parts for the plant.[37] The U.S. Congress reacted further by enacting the Non-Proliferation Act in 1978, giving the President the right to terminate exports of nuclear materials, equipment, and technology to any nation that had detonated a nuclear explosive device or engaged in activities to acquire such a device.[38] After a series of negotiations facilitated by the United States, the French, and then the Chinese and Russians, did supply fuel to India for the operating reactors. An agreement was signed in 1988 with the Soviet Union for two reactors for a site in Tamil Nadu, however, the dissolution of the Soviet Union delayed construction of those reactors for decades. In the end, the international sanctions forced the Indian scientists and engineers to design and build nuclear reactors using the knowledge they had gained over the years to help supply the electricity for the economic development the government, Nehru, and Bhabha envisioned.

Without the rest of the world looking over their shoulders, Indian nuclear experts continued to build the structure for the three stage nuclear power program. As indicated earlier, the second stage will employ Fast Breeder Reactors, fueled by plutonium extracted from the spent fuel of the first stage thermal nuclear reactors, creating additional reactor fuel in addition to generating electricity (thus the name "breeder" reactor). Discussions with the French about designs for a fast breeder reactor started in the late 1960s;[39] by the early 1970s, the DAE and the French Atomic Energy Commission had signed contracts for the supply of fast breeder reactor manufacturing know-how.[40] Indian scientists also journeyed to France to study with the French. The result of this cooperation was the Indira Gandhi Centre for Atomic Research in Kalpakkam, Tamil Nadu, home to the Fast Breeder Reactor Research and

Development Centre. A prototype breeder reactor is now expected to being operation by late 2016.[41]

Construction also continued on reactors across the country. Table 7.1 below shows all commercial reactors that came on-line through 2011.

Table 7.1 Nuclear Reactors in India through 2011[42]

Name	Location	MWe	Commercial Operation
Tarapur 1	Maharashtra	150	10/28/1969
Tarapur 2	Maharashtra	150	10/28/1969
Kaiga 1	Karnataka	202	11/16/2000
Kaiga 2	Karnataka	202	3/16/2000
Kaiga 3	Karnataka	202	5/6/2007
Kaiga 4	Karnataka	202	1/20/2011
Kakrapar 1	Gujarat	202	5/6/1993
Kakrapar 2	Gujarat	202	9/1/1995
Madras 1	Tamil Nadu	202	1/27/1984
Madras 2	Tamil Nadu	202	3/21/1986
Narora 1	Uttar Pradesh	202	1/1/1991
Narora 2	Uttar Pradesh	202	7/1/1992
Rajasthan 1	Rajasthan	90	12/16/1973
Rajasthan 2	Rajasthan	187	4/1/1981
Rajasthan 3	Rajasthan	202	6/1/2000
Rajasthan 4	Rajasthan	202	12/23/2000
Rajasthan 5	Rajasthan	202	2/4/2010
Rajasthan 6	Rajasthan	202	3/31/2010
Tarapur 3	Maharashtra	490	8/18/2006
Tarapur 4	Maharashtra	490	9/12/2005
Kudankulam 1	Tamil Nadu	1000	12/31/2014
Kudankulam 2	Tamil Nadu	1000	10/15/2016

Tarapur 1 and 2 are boiling water reactors, using enriched uranium fuel and ordinary water as a coolant and moderator; the remainder of the reactors on the list use enriched natural uranium as a fuel and heavy water as both a coolant and moderator. Although the DAE has restricted the flow of information about the construction and operation of these reactors, published reviews indicate problems similar to those experienced elsewhere have arisen in India: cost overruns, delayed schedules, and an inability to obtain needed components and equipment.[43] For example, the estimated cost of the Rajasthan 1 reactor in 1964 was R 340 million. By 1977 that number had risen to over R 730 million.[44]

Problems unique to the Indian reactors also have surfaced. After years of delays due to objections raised over the siting of a nuclear power plant in a tropical rainforest, construction of the Kaiga reactors in Karnataka began in 1989.[45] On May 13, 1994, 130 tonnes (140 tons) of pre-stressed concrete slabs of the inner containment dome of Unit 1 crashed to the ground.[46] Initially, the NPCIL blamed the accident on delamination; subsequent inquiries pointed to design flaws as the cause of the problems.[47] The reactor eventually was completed and came on line in 2000. The Narora project in Uttar Pradesh presented a few problems from the start. It was constructed in an earthquake prone region on alluvial soil,[48] increasing the likelihood of accidents and the need to ensure all safety design features worked as planned and to guarantee inspections occurred throughout the construction process and afterward. Design changes incorporated during construction and a problem in the design of steelwork that caused concrete from the ceiling to fall on drilling equipment led to some of the delays. Originally scheduled to begin operation in 1977 and 1978, the reactors began commercial operation in 1991 and 1992.[49] Then, in March of 1993, two blades from the turbine generator of the Unit 1 snapped, sliced through the other turbine blades, and destabilized the rotor system.[50] A fire broke out in the turbine room, knocking out power to the reactor cooling systems and back-up power supply. If the quick thinking reactor operators had not poured liquid boron into the reactor core to absorb neutrons and stop chain reactions (a technique developed in the 1940s), that core might have melted down.[51] The AEC downplayed the seriousness of the accident:

> [T]his kind of failure at Narora has happened for the first time . . . two blades failing . . .
>
> You must remember that as far as nuclear reactor is concerned, there was no problem at Narora. The reactor worked perfectly according to design.
>
> AEC Chairman R. Chidambaram[52]

The Indian safety watchdog organization, the Indian Atomic Energy Regulatory Board (AERB), formed in 1983, then reorganized in 1984. Like the Nuclear Regulatory Commission in the United States, the AERB regulates and licenses and enforces safety regulations at all nuclear facilities in India.[53] The AERB also has responsibility for radiation and industrial safety in the plants. However, as pointed out by the World Nuclear Association, it cannot act totally independently of the other nuclear agencies in India—the Indian AEC and DAE—or the Indian government.[54] The DAE submitted a new Nuclear Safety Regulatory Authority Bill into the Union Cabinet in 2011, but the bill lapsed before action was taken.[55] Under pressure from the IAEA to establish a truly autonomous safety and regulatory board, a revised Nuclear Safety Regulatory Authority Bill was to be heard in the winter session of Parliament in 2015.[56] That did not happen.

As described above, the strong connection between the Indian government, nuclear scientists, and the bodies overseeing the nuclear industry established in the 1940s has continued into the 21st century. Those institutions have remained committed to the ideal that the development of the Indian economy and the provision of electricity to fuel economic growth will come from nuclear technology. These connections are indicated by the red dashed ellipsis in Figure 7.1 below.

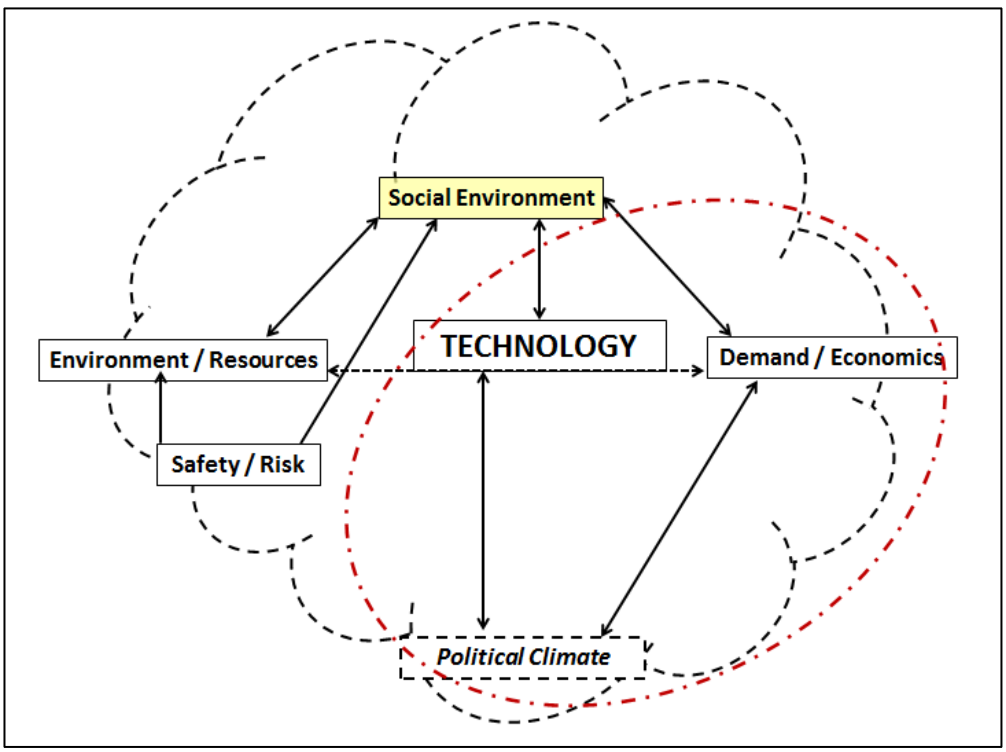

Figure 7.1 The Socio-Political Ecology of Nuclear Power in India

7.2 The Jaitapur Nuclear Power Plant

In 2005, Indian Prime Minister Dr. Manmohan Singh and U.S. President George W. Bush negotiated a ground-breaking agreement that ended the nuclear isolation of India that had existed since the 1970s.[57] According to the Bush administration, the agreement would "[s]trengthen energy security and promote the development of stable and efficient energy markets in India with a view to ensuring adequate, affordable energy supplies and conscious of the need for sustainable development," in addition to opening the door for future technology exchanges, public-private partnerships, and opportunities for investment.[58] Prime Minister Singh's comments to the Indian Parliament on July 29 echoed those sentiments:

> India's quest for energy security as an essential component of our vision for our development was a significant theme of my talks. I elaborated the imperative need for India to have unhindered access to all sources of energy, including nuclear energy, if we are to maintain and accelerate our rate of economic growth . . .
>
> Our scientists have done excellent work and we are progressing well on this programme as per the original vision outlined by Pandit Jawaharlal Nehru and Dr. Homi Bhabha. We will build on this precious heritage . . .
>
> Energy is a crucial input to propel our economic growth. We have assessed our long term energy resources and it is clear that nuclear power has to play an increasing role in our electricity generation plans. While our Indigenous nuclear power programme based on domestic resources and national technological capabilities would continue to grow, there is clearly an urgent necessity for us to enhance nuclear power production rapidly. Our desire is to attain energy security to enable us to leapfrog stages of economic development obtained at the least possible cost. For this purpose, it would be very useful if we can access nuclear fuel as well as nuclear reactors from the international market. Presently, this is not possible because of the nuclear technology restrictive regimes that operate around us. What we have now agreed with the United States should open up the possibility of our being able to access nuclear fuel and nuclear power reactors and other technologies from outside to supplement our domestic efforts.[59]

The agreement was signed into law by the U.S. Congress in 2006.

That same year, the Indian government agreed in principle to build two 1,000 MWe nuclear reactors at a site at Jaitapur in Taluka Rajapur, Ratnagiri, Maharashtra.[60] The Nuclear Power Corporation of India, Ltd. (NPCIL) received authorization from the DAE to initiate pre-project activities, including undertaking an Environmental Impact Assessment (EIA) study and receiving environmental clearance for the project. (Although originally requested for two 1000 MWe reactors, the EIA was later updated to cover six - 1650 MWe units at the site.) The site selection criteria in the EIA document reveal that the site was chosen as suitable for holding three twin 1000 MWe units. Key features of the chosen area listed in that document include:

1. Adequate land, rocky and almost barren;
2. Fresh water available from a desalination facility of seawater assured at the site;
3. No active fault within a radius of 39 km of the site;
4. An average elevation of 24.5 m above the mean sea level (safe in terms of flooding or tsunami);
5. No population centers of more than 10,000 within 10 km of the site;
6. No sensitive species within 5 km of the site.

About 1/3 of the local population engages in fishing, mainly trawling, purse seine, and gill netting, and some netting closer to shore. The six reactors have been designed to discharge their cooling water off-shore, into areas now used as fishing grounds by the villagers. However,

> ". . . thermal dispersion studies carried out by CWPRS [Central Water and Power Research Station, Pune] shows that the maximum temperature rise of 4 – 5 ^{o}C will be confined to a limited area and hence sill not adversely affect the native flora and fauna under normal ambient conditions."[61]

In the end, according to the National Environmental Engineering Research Institute, the "impact on environment arising out of human utilization is insignificant".[62]

In 2008, the International Atomic Energy Agency (IAEA) approved India's safeguards agreement for civilian nuclear reactors (but not those used for military purposes), allowing the IAEA to verify that those particular facilities were being used for peaceful purposes only.[63] That in turn paved the way for India to access state-of-the-art nuclear technology of other nations. France and India signed an intergovernmental agreement on cooperation in the peaceful applications of nuclear energy in September of that year. And although the French nuclear company, AREVA, had established a foothold in India with a bioenergy project beginning in 2003, it quickly followed suit by establishing a subsidiary in Mumbai in November.[64] In 2009, AREVA and NPCIL signed a Memorandum of Understanding (MoU) to build up to six European Pressurized Reactors (EPRs) at the Jaitapur site in Maharashtra and to supply a lifetime of fuel for those reactors. Construction agreements for the first two reactors were signed December, 2010.[65]

In 2010, the Jamsetji Tata Centre for Disaster Management of the Tata Institute of Social Sciences (TISS), Mumbai, published its "Perceptions Matter: Social Impact Assessment of the Jaitapur Madban Nuclear Power Plant."[66] The Centre had been asked by Bharatiya Paryavaran Chalval (Indian Environment Movement) and Janahit Samiti, Madban (People's Committee, Madban) to undertake the Social Impact Assessment of the project. (Note: India's 2007 National Rehabilitation and

Resettlement Policy, Chapter IV, Section 4.1, requires a Social Impact Assessment be performed for any project displacing 400 or more families or 200 or more tribal families.[67]) Two students and Dr. Mahesh Kamble journeyed to the area, and met with people from the villages and local leaders and gathered data from them about the social consequences of the project. Government officials were not forthcoming with information and, due to time constraints; they were unable to file Right to Information requests. Their report thus became a "people's report" on the impact of the proposed facility.

The TISS report raised a number of points not addressed in the EIA, including the confusion on the part of the local people about the information being presented to them by the government and NPCIL. All of the villagers had experienced minor seismic activity and yet the land has now been re-classified as being in seismic zone three and was considered safe for the construction of a nuclear power plant.[68] The amount of land being acquired for the project varied from document to document: from 700 to 938 to 990 hectares. The government and NPCIL also indicated much of the land is barren. Even so, the government had compensated over 33,000 farmers in the Rajapur block (which includes the villages of Madban, Karel, Mithgavane, and Niveli) nearly Rs 13,707,000 in 2009 for lost mango production due to floods that occurred in 2007.[69] Such discrepancies led the people to doubt other government claims that the plant would bring new business opportunities or employment for them in the area; instead they feared the harmful effects of radiation on crops, fish, and human health. According to one of the villagers who participated in the project,

> Our Konkan has the blessing of god and that's why our land is so rich. God has given green fabric to this area. However, coal and nuclear power plants will strip us of this fabric, leaving us naked.[70]

NPCIL responded to the TISS report saying it was a compilation of people's opinions, a people's report, and not a scientific one.[71]

Figure 7.2 Village Across from Jaitapur Nuclear Power Plant Site, March 2015

The catastrophic earthquake and tsunami that crippled the Fukushima Dai-chi Nuclear Power Plant in Japan in March 2011 did not deter government support for the Jaitapur project. Union Agriculture Minister Sharad Pawar told reporters "One has to see how to overcome natural calamities. It is wrong to stop forces of development . . . We have to construct power plants whether they are nuclear, gas based, hydro or coal."[72] Likewise, Environment Minister Jaimarm Ramesh assured the public that the Jaitapur project would continue as planned. Safety systems would be reviewed, but in light of the energy needs of India, there was no alternative to nuclear.[73]

Prime Minister Narendra Modi took office May 26, 2014. Like many of his predecessors, Modi has made large scale projects a hallmark of his administration. During his third term as Chief Minister of Gujurat he focused on groundwater recharge projects, irrigation canal construction, and bringing electricity to all parts of the state. As Prime Minister, he has visited France to negotiate reduced costs on the AREVA reactors by incorporating Indian suppliers, thus also ensuring a transfer of technology from French to Indian engineers and scientists.[74] On April 16, 2015, Modi and Prime Minister Stephen Harper of Canada signed a ground-breaking deal under which Canada will supply 3,000 metric tonnes (about 3,300 tons) of uranium to India under a $254 million five-year deal to power Indian's nuclear reactors.[75] This deal put an end to the Canadian ban on uranium exports to India that had taken effect in the 1970s and began what Modi described as a "natural partnership of shared values."[76] In June 2016, Modi and President Obama took the initial steps towards a new agreement between NPCIL and Westinghouse (now a U.S. unit of Toshiba Corp.) for engineering and site design work for a nuclear power complex housing six AP 1000 reactors, a design now certified by the U.S. Nuclear Regulatory Commission and under construction at the Vogtle Electric Generating Plant in Georgia.[77] Details of the agreement will be finalized in 2017. In 2014, Modi urged the DAE to triple India's nuclear capacity by 2024.[78] While that may not be realistic given the lead time for nuclear power plants, Prime Minister Modi clearly supports nuclear power.

As of this writing, negotiations have continued between the Indian government, NPCIL, the French government, and AREVA over the price at which the electricity generated by the Jaitapur reactors will be sold, and over credit financing. Liability issues also have come to the forefront. The International Atomic Energy

Agency's "1997 Vienna Convention on Civil Liability for Nuclear Damage" indicates that the operator of a nuclear power plant assumes the liability for damages should an accident occur, except as the result of wartime activities. AREVA and its suppliers expect the Indian operators to adhere to that Convention and expect to not be held liable for any accidents that occur after they complete the construction of the plant. Of concern is language in the Indian Civil Liability Nuclear Damage Act of 2010. According to that Act, the operator of the nuclear plant remains responsible for all damages that occur as the result of an accident, and the victims need not prove fault, or willful negligence, merely that the accident has happened.[79] The extent of operator liability has been capped at Rs 1,500 crores (Rs 15 billion). However, the Nuclear Damage Act allows the operator to pursue litigation against a supplier in the case of faulty design, latent defects of material, or sub-standard services.[80] In essence, the operator can sue the supplier in Indian courts long after they have taken control of the nuclear power plant. Until the exact detail of the extent of liability of foreign suppliers has been codified, this and several other nuclear projects remain on hold.

7.3 Local Response

The news of two nuclear reactors of French origin for the Jaitapur site came as a surprise to many. According to Dr. Bhikaji Waghdhare, land owner from the Jaitapur area, now partially paralyzed and residing in Mumbai, a local representative in Parliament gave out a letter in 2000 telling the locals a thermal plant was to be built on the land.[81] Two years later, they were told the plant would be a nuclear plant. The plan then increased to two, then possibly six reactors at the site. Unlike Dr. Waghdhare, most people found out about the propose plant from reading the newspaper.[82]

NPCIL representatives did visit the Jaitapur area twice in 2006 (in Mithgavane) and once in 2006 (in Madban), according to their own log book of meetings related to the Jaitapur Nuclear Power Project.[83] At the meetings, the NPCIL provided information about the project. According to villagers in Tulsunde, the NPCIL officials came and told their story, explained their reasoning, and tried to convince the audience of the benefits of the nuclear power plant. But the NPCIL did not listen to the local people.[84] Meetings in 2009 and 2010 tended to be held in the NPCIL headquarters in Mumbai. Meetings were held in three different local villages in January of 2011 and another in November, 2011. NPCIL representatives visited twice more in 2012. Meetings arranged after February 2012 have been held at the Jaitapur Nuclear Power Plant Information Centre in Ratnagiri. While asking interested parties to travel to the Information Centre makes it easier for project officials to be present, to show their PowerPoint slides, and distribute handouts, it requires villagers and others to take time off of work to travel to the site, and find and pay for transportation.[85] For the farmers and fishermen of the villages near Jaitapur who have limited incomes, that represents a big expense in terms of both time and money. Based on the entries in the NPCIL logs, less than 5% of the NPCIL meetings between November 2005 and July 2016 were with people from villages adjacent to the project site.[86]

NPCIL had started taking title to the land needed for the Jaitapur Nuclear Power Project in 2005, even before contracts had been signed with suppliers and before notices were sent to the landowners.[87] Approximately 938 hectares (2,318 acres) have been acquired.[88] The process was guided by the Land Acquisition Act of 1894, still in place at the time. That Act allowed land to be taken for public purpose projects in exchange for a fair rate of compensation.[89] In the case of the Jaitapur project, Dr. Waghdhare indicated that the government had used an emergency land acquisition procedure usually reserved for cases of natural disasters. Article 17 of the Land Acquisition Act allowed the government to bypass other procedures:

> In cases of urgency, whenever the appropriate Government or the Commissioner so Directs, the Collector, though no such award has been made, may on the expiration of fifteen days from the publication of the notice mentioned in section 9, sub-section (I), take possession of any land needed for a public purpose. Such land shall thereupon vest absolutely in the Government, free from all encumbrances.[90]

However, in this case, the government and NPCIL did offer the landowners compensation for their lost land. The original offer was Rs 2.86 / sq. ft. for barren land and Rs 3.70 / sq. ft. for cultivable land (the equivalent of Rs 125,000 per acre for barren land and Rs 160,000 for cultivable land).[91] Only absentee owners accepted that low payment. People living in the villages around proposed site argued that their land was not barren at all—they grew mango and cashew trees, and rice; their cattle grazed on the grasses that sprouted after monsoon; they even used the gravelly red dirt in making bricks. A mango farmer could expect to invest Rs 50,000 per acre the first year and Rs 25,000 for the next 8 – 10 years preparing and maintaining the land, watering and pruning the trees, and in labor. For those efforts, he would receive an income of Rs 10 – 15,000 per well-grown tree.[92] The compensation offered would by no means cover their investment or the expected income from their land. Over time, the offer of compensation increased to almost Rs 1 million per acre plus one job per project affected family.[93] More and more families have relented and accepted the compensation offered.[94]

No homes were lost in the land acquisition, which in turn meant no families were officially displaced by the project.[95] Indeed the Union Minister of State under Prime Minister Singh assured the Indian Rajya Sabha (Council of States in Parliament) in 2012: "There is neither displacement of people at the site nor any requirement of resettlement of any person."[96] However, because families lost their land, many lost the only means they had of earning an income and feeding their family and their animals. Without access to land, they will be forced to buy food. Before the Jaitapur project they were self-sufficient; now they have to depend on others for everything.[97]

Although the villagers of the Jaitapur area could refuse compensation, they could not challenge the level of compensation in court. Using a special amendment to the Land Acquisition Act written specifically for this project, the government declared that no one could challenge the compensation either by petition or in court.[98] Thus, unlike Medha Patkar's ongoing challenges along the Narmada, and fights against other large development projects across India, no lawsuits have been filed over compensation.

Instead, people have taken to the streets. Between August 2007 and October 2009 members of the government invoked Section 37 (1) (3) of the Bombay Police Act to try to stop this form of dissention. [99] This Act prohibits gatherings of more than five people at any given time and place. Police arrested villagers, served notices of externment on peaceful protesters, pressed false charges against agitators, refused bail, and refused entry into the area to anyone wanting to demonstrate with the protestors. Small farmers, and even doctors and members of the legislative assembly found themselves in jail, and forced to visit the police station in Rajapur on a weekly basis while awaiting prosecution.[100] Some agitators have been refused passports in an effort to pressure them not to protest.[101] Seventy schools in the area closed for a day as a mark of protest against the proposed projects.[102] The demonstrations against the Jaitapur Nuclear Power Plant united fishermen and farmers, shopkeepers and schoolteachers, men and women, Muslims and Hindus in an effort to make their voices heard. Unfortunately, as protests continued, they took a deadly turn when police killed Tabrez Sagvekar, 28, on April 18, 2011 as a mob of 600 – 700 people began ransacking a district hospital and torching buses in Madban.[103]

Figure 7.3 Town Water Well, Sakharinate, “AREVA GO BACK”, March 2015, Image by the Author

Although the local agitations have died down, the opposition to the nuclear power project has not. The Shiv Sena, a far right Indian nationalist party, stands against the Jaitapur project and has vowed to scrap it if voted into power in Maharashtra.[104] In 2015, party members called for their own protest marches and initiated a boycott of NPCIL workers in Ratnagiri, asking shopkeepers not to sell goods to them.[105] What started as a personal fight for family, land, and livelihoods, has now become part of a more impersonal political one.

7.4 In Closing

Chapters 5, 6, and 7 have demonstrated that since the 1940s, government officials, academicians, and industry stakeholders in the United States, the former Soviet Union, and India have clung to a belief in the possibilities of the power of the atom. (The nuclear trajectories adopted by these nations are summarized in Tables 5.3, 6.1, and in 7.2 below.) Those possibilities have included the swift end to bloody wars; electricity generation without the reliance on fossil fuels; and economic development and prosperity. The nuclear industry statisticians continue to reassure stakeholders that the probability of damage to a reactor core is only one in 100,000 for reactors like those operating in the United States.[106] Yet such an estimation of "probable security" vanishes quickly in the face of a hydrogen explosion or a tsunami wave.[107] The reality of a catastrophic reactor core melt-down or decades of toxic waste collection and need for clean-up then brings to the forefront the less widely publicized risks of nuclear technology—the radiation exposure, radiation sickness, thyroid cancer, toxic plants and animals, the need to develop new technology to contain radioactive waste, and necessity of fencing off large swaths of land for hundreds or thousands of years to protect people from the radioactive materials stored there.

The decisions made to rely on nuclear technology also have a great impact on the social environment, on people--from the time choices are made to acquire land until the final weld seals a new containment structure in place. Chapter 8 explores how nuclear technology results in the physical and psychological displacement of people throughout this lifecycle using the Process Model of Displacement outlined in Chapter 3. The voices of the people of Jaitapur, Hanford, and Chernobyl help reveal the displacement that occurs during the planning, construction, operations, and legacy phases of a nuclear technology project.

Table 7.2 An Overview of the Nuclear Power History of India and Jaitapur

(Events related to the Jaitapur Nuclear Power Plant in italics)

Phase	**Month**	**Year**	**Event**
Planning			
		1945	Tata Institute of Fundamental Research founded; Homi Bhabha appointed director
	Aug	1947	Indian Independence Act took effect
		1948	Prime Minister Jawaharlal Nehru advocated to the Indian General Assembly in favor of nuclear energy
		1948	Atomic Energy Act of 1948 passed
		1948	Atomic Energy Commission (Indian AEC) established under Indian Ministry of Natural Resources and Scientific Research
		1954	Department of Atomic Energy (DAE) emerged
		1954	Bhabha Atomic Research Centre (BARC) established--the start of India's nuclear R & D program
	Aug	1956	First experimental reactor operational, a pool-type reactor
		1960	CIRUS research reactor started functioning at the Bhabha Centre
		1962	Revised Atomic Energy Act passed
		1964	Indian scientists began researching reprocessing nuclear fuels
Construction / Operations			
		1969	Tarapur Atomic Power Station completed, India's first commercial nuclear power plant
		1973	First unit at the Rawatbhata, Rajasthan Atomic Power Station came on line
		1974	India's first nuclear weapons tested, resulting in the withdrawal of international support for Indian nuclear programs
		1983	Atomic Energy Regulatory Board (AERB) established
		1983	Atomic Energy Arbitration Procedure Rules established under the Atomic Energy Act

Table 7.2 continued

		1984	Atomic Energy Working of the Mines, Minerals and Handling of Prescribed Substances Rules set forth
		1987	Atomic Energy Safe Disposal of Radioactive Waste Rules encoded
	May	1991	Research reactor at BARC operated for almost a month with a malfunctioning emergency cooling system
	March	1993	Near meltdown at the Narora Atomic Power Station, Uttar Pradesh
	May	1994	Collapse of a portion of the pre-stressed concrete dome during construction of the Kaiga project in Karnataka
		1996	Atomic Energy Factories Rules created
	March	1999	Heavy water leak at the Kalpakkam Nuclear Power Station, Madras; seven technicians removed from duty after receiving heavy doses of radiation
		2004	Atomic Energy Radiation Protection Rules established
		2005	Passage of the Right to Information Act--does not apply to the nuclear industry for reasons of national security
		2005	US-India Joint Statement issued
		2005	Weapons of Mass Destruction and their Delivery Systems (Prohibition of Unlawful Activities) Act passed
		2005	*NPCIL representative visits the local village of the Jaitapur area for the first time (Mithgavane)*
		2005	*NPCIL started taking title to land for the Jaitapur Nuclear Power Project*
	Feb	2006	Guidelines for Nuclear Transfers (Exports) created
		2006	*Indian government agreed in principle to build two 1000 MWe nuclear reactors at the Jaitapur site in Ratnagiri, Maharashtra*
		2006	*NPCIL received authorization from DAE to undertake an Environmental Impact Assessment and other pre pre-project activities*

Table 7.2 continued

	Aug	2007	Agreement for Cooperation between the Government of the United States of America and the Government of India Concerning Peaceful Uses of Nuclear Energy signed into law
		2008	Nuclear Suppliers Group (NSG) relaxed guidelines for civilian nuclear commerce
		2008	“Agreement between Government of India and the International Atomic Energy Agency for the Application of Safeguards to Civilian Nuclear Facilities” opened India to uranium imports and technological cooperation with other nations
		2009	*AREVA of France and NPCIL signed a Memorandum of Understanding to build six reactors at the Jaitapur site*
		2010	Civil Liability for Nuclear Damage Act enacted
	July	2010	Guidelines for Implementation for Arrangements for Cooperation Concerning Peaceful Uses of Atomic Energy with Other Countries outlined
	Nov	*2010*	*Environmental Clearance for the Jaitapur Nuclear Power Project received from the Ministry of Environment and Forests for the first phase of two units*
	Dec	*2010*	*Construction agreements between AREVA of France and NPCIL signed for two reactors at Jaitapur*
	Dec	*2010*	*Jaitapur project received CRZ clearance from Ministry of Environment and Forests for six units*
		2011	Nuclear Safety Regulatory Authority Bill drafted by DAE and submitted to the Union Cabinet; eventually lapsed
	March	2011	Fukushima Nuclear Accident in Japan
	April	2011	*Local citizen killed in protests against the Jaitapur Nuclear Power Plant*
		2013	Public Accounts Committee of Parliament produced "Activities of Atomic Energy Regulatory Board" supporting the need for an independent, empowered nuclear regulator
	May	2014	Prime Minister Narendra Modi took office
		2014	Modi encouraged the DAE to triple India's nuclear capacity by 2024

Table 7.2 continued

	April	2015	Modi signed a deal with Prime Minister Harper of Canada for a supply of 3,300 tons of uranium for India's nuclear reactors
		2015	*Shiv Sena took on the Jaitapur Nuclear Power Plant on as a party issue*
		2015	Revised Nuclear Safety Regulatory Authority Bill submitted to Parliament

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104 “Jaitapur Project to be Scrapped if Sena Comes to Power: Uddhav Thackery,” October 12, 2014, http://zeenews.india.com/news/maharashtra/jatiapur-project-to-be-scrapped-if-sena-comes-to-power-uddhave-thackery_183646.html; “Jaitapur Nuclear Project: Shiv Sena Takes Issue to PM Modi,” *Business Standard*, December 16, 2015, http://www.business-standard.com/article/pti-stories/jaitapur-nuclear-project-sena-takes-issue-to-pm-115121600157_1.html.

105 “Shiv Sena ups Ante Against Jaitapur Nuclear Project,” *The Tribune*, March 25, 2015, http://www.tribuneindia.com/news/nation/shiv-sena-ups-ante-against-jaitapur-nuclear-project/58216.html.

106 World Nuclear Association, “Safety of Nuclear Power Reactors,” May 2016, http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx.

107 See Ulrich Beck’s “The Anthropological Shock: Chernobyl and the Contours of the Risk Society,” *Berkeley Journal of Sociology* 32 (1987): 153 – 165.

Chapter 8

THE PROCESS OF DISPLACEMENT ASSOCIATED WITH NUCLEAR TECHNOLOGY

My father was born in Schwetzkingen, Germany in 1898. He took place in the First World War in Germany and after the war, he wanted to work with agriculture to become a farmer . . . He came to America, first New York and then Seattle in 1926, as far as I know . . . he was then able to purchase this farm with, I assume, some money coming from Germany. Four hundred acres that was fenced in with an icehouse was surely a big project and several buildings with silos and so on.

One day, I remember two military jeeps driving in and these people saying, "We have papers that say this is going to become the Hanford atomic bomb project and you will have to move out within two months," which was a real challenge for a farmer.

Ludwig Bruggemann, from a farm family of White Bluffs, WA, evicted to make way for the Hanford Nuclear Reservation[1]

Interviewer: What happened to those who worked at the Chernobyl power plant after the explosion? Do you know the stories of those people? How many survived?

Evgeny Akimov: I don't have the statistics about how many of us are already dead. I think it's quite a lot. Disability accounts for 60,000 or 70,000 out of the 650,000 rescuers. In fact, the Chernobyl tragedy affected my whole family. Being a professional, I understood that there was no one to do that job except for the professionals. It is clear. Second, my wife dealt with nuclear energy, and she also visited the Chernobyl nuclear power plant. Regrettably, today, she has cancer. After several serious operations, she is now, though it is hard for me to

> say, a person with very limited physical abilities. But she is not the only one. There are many people like her.
>
> Evgeny Akimov, Nuclear Engineer from the Chernobyl rescue operation in an interview days after the Fukushima Dai-ichi, Japan accident in 2011[2]

Physical, social, emotional, and psychological displacement occur from the time ideas begin to circulate for a nuclear technology project through land acquisition, construction of reactors and ancillary buildings, operation of the site, and its legacy phases. The model of the ongoing process of displacement, first introduced in Chapter 3, is presented in Figure 8.1 below. Each section that follows focusses on one of the phases in the process, from Planning through the Legacy Phase. Figure 8.1 also indicates the case studies used to illustrate the displacement that occurs during each of the phases. The case shown in regular font are the primary sources of data; the one shown in parentheses provide secondary information.

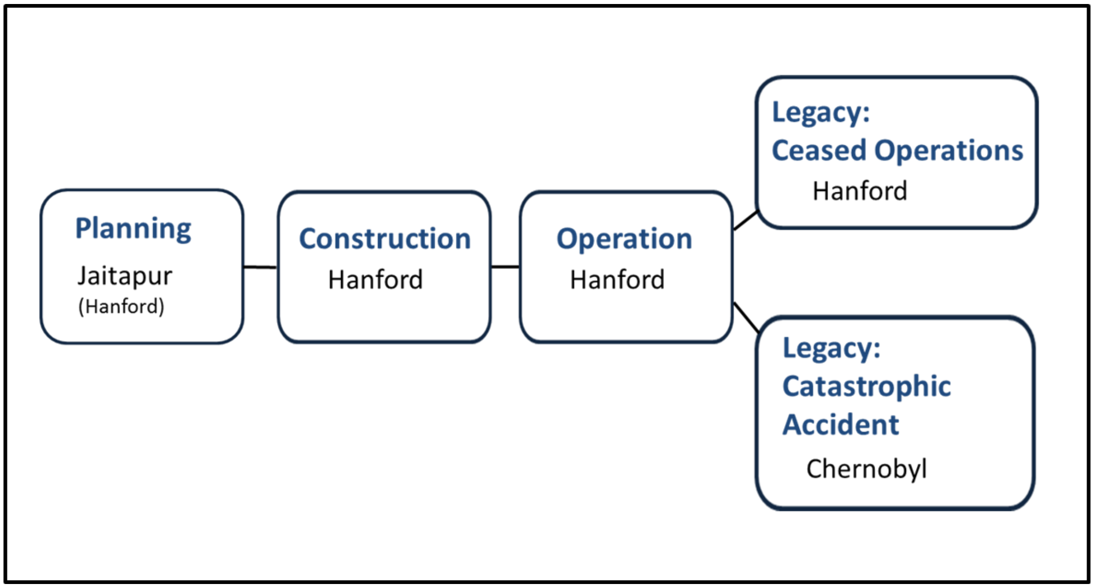

Figure 8.1 The Process Model of Displacement for Nuclear Technology

8.1 The Planning Phase

During the Planning Phase of a nuclear technology project, typical activities include finding and acquiring the land needed; obtaining financing; complying with local, regional, and national permitting obligations; interacting with the public in the area where the facility will be located; and communicating with local utilities and businesses. For government authorities, company officials, and others involved in planning, many of the activities involve measurements, counts, and calculations; making detailed lists and schedules; and following rules and protocols. The people involved in planning a nuclear technology project usually are not those with ties to location chosen for the project. They do not have experiences there; they do not have connections to it. According to the terminology introduced in Chapter 3, to them it is an undifferentiated space, not truly a place. They know it by its characteristics—its dimensions, the availability of cooling water, the distance from centers of population—rather than by personal associations they have with it. Yet their planning activities do affect locations where families have lived for generations, locations around which people have built their lives, locations that form the centers of vibrant communities. This section of Chapter 8 covers the physical and psychological displacement that can result from planning activities of a nuclear technology project using examples from the Jaitapur and Hanford projects.

8.1.1 Land Acquisition

One very emotionally charged instance of displacement during the planning phase occurs when people lose title or access to their land to make way for a large nuclear technology project. At Hanford, Colonel Matthias found himself dealing with an unexpected group: the Wanapum. Unlike the settlers who had deeds to the land, and houses, crops, and equipment that could be appraised, the Wanapum claimed rights to the region based on stories handed down for generations, a yearly cycle of fishing, camping, berry picking, collection and storage of natural foods and medicines, and the burial of ancestors in sacred areas of the chosen site.[3] The Wanapum had no official treaties to back their claims. As explained by the son and grandson of those who negotiated with Colonel Matthias,

> The Indian is part of the land, you know. The Indian is the land. And that's just the way it is. There's no difference about it. You know, that's just how it is. That's how the connection is the—we are part of this land. Our people are here, generations upon generations were put here and we're always going to be here.
>
> Rex Buck, Wanapum[4]

The Wanapum did not want monetary compensation for the fish they would no longer be able to catch. They wanted to be able to continue their cultural traditions, to be able to honor their ties to the earth, and to perform the ceremonies of their forefathers.

> It was finally agreed that we provide the Indians with a truck and driver who will, at their request, during the fishing season haul the Indians and the fish from White Bluffs to their camp at Priest Rapids once a day. This would permit the Indians to do their fishing under supervision, it would avoid the necessity of their living and sleeping in the area, and would assure them of as much fish as they get now. A cash settlement, to be paid annually for their privilege to fish and be in that part of the River was rejected by the Chief.
>
> Colonel Matthias[5]

The tribe invited Matthias to their Spring Festival and eventually was granted passes to the Hanford site, assuring them a continuing level of independence.[6] However, once the bombs fell on Japan, the passes were revoked. The Wanapum did not regain access to their ancestral lands within Hanford until the 1960s—this time under armed guard.[7] They were treated as "outsiders" by the people who had taken over much of their lands.

> And they continued to live like that, even in the areas that were restricted, you know, they made pleas to come out to visit the sites in Hanford. Even though they were under heavy guard, during those times, military guard to visit sites, they visit sites, they did things that they had to do and carry on the best that they can.
>
> And then as time went on, they always continued to develop those relationships with the Atomic Energy Commission and Department of Energy, so that they could be heard about the things that were important to them, the things that they wanted protected and the things that they wanted preserved and the sensitivity of those thing. And that's what they did, is they continued to work towards those kind of goals, to make sure that their presence was unbroken . . . they continued

> to seek whatever alternatives there were to maintain what was important to them.
>
> Rex Buck, Wanapum[8]

The Nez Perce, Confederated Tribes of the Umatilla, and the Confederated Tribes and Bands of the Yakama Nation also had used the area for hunting and fishing. They would meet along the Columbia River for trading purposes.[9] Marriage ceremonies occurred. But World War II changed that.

> [I]t affected our lives, our fishing and our gathering of our food. Lot of the places where the elders would go and hold ceremonial services was being affected because we couldn't go there anymore. And so I know that, to us, this hasn't—it has hindered our lives quite a bit, changed our lives and our lives to this day is changed and it has affected us.
>
> [A] lot of the activities that were going on before had stopped. A lot of our contacts we had with other tribes have stopped because we were no longer able to come this way on our regular route that people traveled over the same lands and things. Usually there was a path that people took and when they couldn't come—use the same path all the time, it had changed and changed the way—then eventually we would lose contact with some of those people. And we would lose contact with some of the food and things that we used to trade with and for in this area.
>
> Veronica Taylor, Nez Perce[10]

While the U.S. Army worried about the property rights of settlers in small towns of White Bluffs and Hanford, and worked with lawyers to hammer out contractual deals for homesteads and farms (explained in more detail in Chapter 5), the Native Americans lost their connections to other tribes, their ability to harvest medicinal foods, and the freedom to take their children to places they had enjoyed as youngsters. They received no settlement. And yet the tribal members and the citizens of the Yakima nation had been physically and culturally displaced.

8.1.1.1 Compensation Issues

At both Hanford and in the Jaitapur area, official policies dictated that owners receive monetary compensation for land taken as part of a nuclear technology project. That would be a simple solution if all rights to the land were written down and recorded in government offices, if no mistakes were made in the process of assessing the value of property or paying the compensation, and if money could actually replace what people had lost. That was not the case at Jaitapur. The map in Figure 8.2 below will give the reader a sense of the locations of many of the villages mentioned in the text that follows.

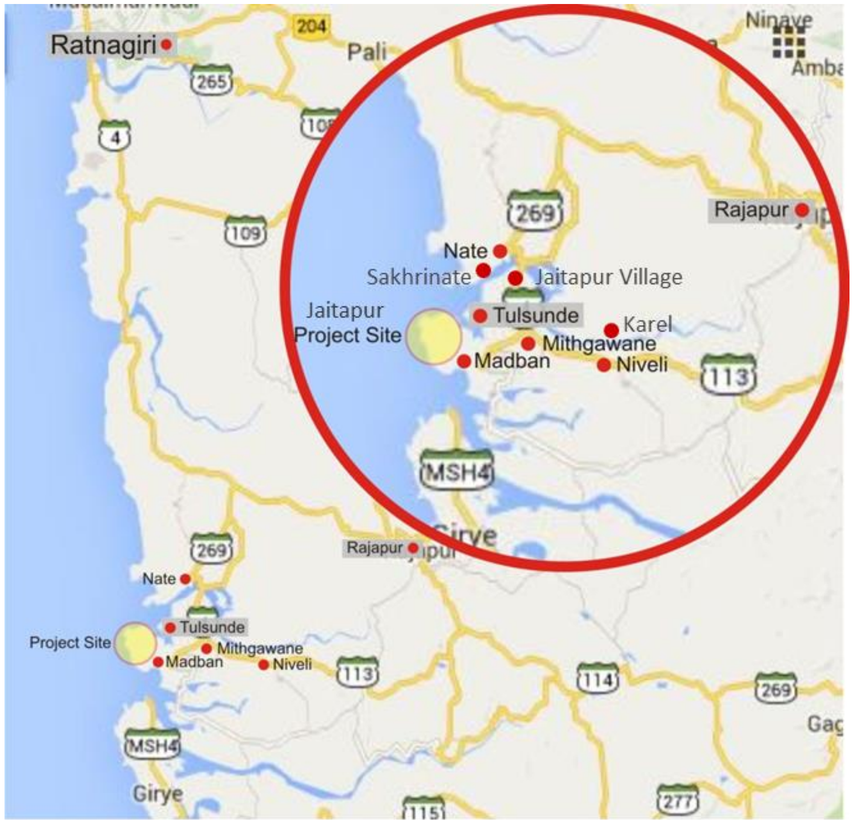

Figure 8.2 Map of the Jaitapur Nuclear Power Plant Location[11]

In most places, the owner of the land would be the person(s) whose name(s) appears on the deed. However, by tradition, in these Indian villages the father passes the land on to his oldest son.[12] Some families with emotional connections and intergenerational ties to the land make conscious decisions not to change the names on the deed.[13] Thus, land conveyances often do not get recorded. It has been the oldest sons and their sons who have worked the land, invested time and money in nurturing the land. Other siblings often have left to find jobs in the cities, in Mumbai or Pune. According to villagers in Madban, when the government gave out the compensation for the land, all those whose names were associated with the parcel of land received an equal share, not just the person working the land. That also meant any amount the government paid had to be divided among the decedents of the original purchaser, each one often getting only a small amount. The current farmer and his family had little left to live on. Fishermen in nearly villages who have been supporting relatives in Madban wonder if they should continue to do so, since those family members had received money as part of a land settlement.[14] Stories like these made it fairly clear that the fighting over money has left families divided and family members feeling bitter.

In some cases there was confusion about who really owned which parcel of land. In Niveli, the government representatives gave out the compensation without requiring documentation of ownership. That led to some people who did not own land to claim money to which they were not entitled.[15] In addition, cousins who had no claim to ownership, demanded part of the payment.[16] Now the government demands proof of ownership.

The government also overpaid a number of families and then, a year and a half later, asked for the return of a portion of the money.[17] In one case, much of the money already had been spent by an alcoholic family member, and the one family member remaining in the area must shoulder the burden of repaying all of the overpayment. In another case, all of the money has been spent and the land is gone. The family has no means of generating funds to repay the government. In one village, 36 of 400 families received word they had to repay part of the compensation they had received.[18] They cannot understand why poor families must pay for the government's mistakes.

Some landowners took their compensation and left for the big cities. Others used it to erect elaborate houses in their villages. The painted facades and ornate gates stand out from the earthen colored dwellings around them. But will they have enough money to maintain those fancy structures? The mere awareness of some families having received money for their land has caused rifts between people in some of the villages. Those without money have begun telling officials to turn to those with money when the town needs help with development projects.[19] Money has divided the once unified villages.

Officially, not one person was displaced for the Jaitapur Nuclear Power Plant. Still, the issue of compensation has displaced many people and communities. Family ties have been strained. Community connections have been severed. And yes, people lost land. While they did retain their dwelling, they relied on the land for sustenance and for income. They had a roof over their heads but nothing to eat and little money with which to purchase food. Additionally, for many, that land gave them an identity. They were proud to call themselves Alphonso mango farmers or cashew farmers. Being farmers also brought rhythm and order to their lives, rhythms based on the rhythms of nature, the rhythm of monsoon and dry seasons. The communities and relationships in those communities emerged around peoples' identities as farmers and their needs as farmers. All of that has been *now* changed. They can't plan. They can't plant.[20] The only lives they have known for generations have been taken away from them.

The loss of land and the government's imperfect attempt to compensate the owners for that loss has left the people of the Jaitapur area physically and emotionally displaced.

8.1.1.2 Putting Up Walls

Figure 8.3 Jaitapur Nuclear Power Plant Border Wall, March 2015, Image by the Author

Long before the final contracts had been negotiated for the Jaitapur project, the Nuclear Power Corporation of India, Ltd. (NPCIL), had begun to erect tall concrete, barbed-wire topped walls around the property acquired for the project—the plant and housing compound for the workers (See Figure 8.3). The walls have become a very powerful sign of the project in the lives of the villagers, standing in stark contrast to the red earth and green hills around them. They remind the villagers who now owns the land. They underscore the fact that villagers can no longer graze animals, or plant or tend the crops on the lands enclosed. The villagers have become outsiders on what was their land.

In addition to enclosing purchased land, the completion of one wall will completely cut off the access of the village of Niveli to the main road.[21] People residing there will no longer have access to food and other supplies. Will the government build a new road to the town? Even if a new road does get constructed, the people of Niveli feel they will need to relocate eventually. They worry about the availability of drinking water and the rising costs of foodstuffs. But where will they go? Who will pay for them to move? To whom do they turn to find out? The government and project officials tell them nothing. They have already lost their livelihoods. They feel they will need to leave their homes. Physical displacement will follow the psychologically displacement they already have suffered.

8.1.2 Controversy Over the Environmental Impact Assessment

The National Environmental Engineering Research Institute (NEERI) undertook the Environmental Impact Assessment (EIA) for the Jaitapur Nuclear Power Plant project in 2006, as explained in more detail in Chapter 7. The EIA contains pages and pages of maps, data, tables, and calculated information about the site itself and the region. It has used the scientific method to observe, classify, and document information about the geology, biology, and hydrology of Jaitapur. The conclusion: “Impact of Nuclear Power Plant (NPP) operations on surrounding environment is negligible.”[22]

NEERI failed to incorporate local environmental knowledge into its assessment. Nor did it respond to local concerns in reaching its conclusions. Scientists did not value the villagers’ experiences, despite their having lived and worked in the area for generations. For example, many in Jatiapur Village (from which the power plant takes its name) had felt earthquakes—at least one per year.[23]

Advocate Girish Raut of Mumbai had found a 2014 report listing all the faults in the area.[24] One cuts right across the Madban plateau; a fault in Rajapur (32 km or about 20 miles away) produces a thermal spring every three or so years. Yet the EIA declared "there is not earthquake activity around the Jaitapur site in a radius of 39 km."[25]

The rusty red earth used for the bricks found in many of the houses in the region cannot withstand the weight of the heavy nuclear structures. The EIA indicates that building the power plant will require excavating down 20 – 30 m to reach a basalt foundation.[26] However, locals worry about the strength of the basalt. It too cracks and crumbles due to water infiltration from above and wave action from the coast (See Figure 8.4).

Figure 8.4 Crumbling Foundations, March 2015, Image by the Author

A breakwall structure to act as a barrier to the waves was proposed to protect the site; however, analysis of the impact of the construction or presence of that 2,300 meter long wall on the marine environment was not part of the 2006 assessment.[27] Fishermen in Nate worry about the impact the breakwall will have on currents where the river meets the sea.[28] The people in Jaitapur Village noticed that blasting and pouring concrete for a local bridge project reduced the take of shrimp from the nearby hamlet from one truckload per day to none.[29] They fear their harvest of mollusks will suffer a similar fate if something like the breakwall gets built. They rely on mullusks for a large portion of their earnings. The women of Sakhrinate echo the concerns of those in Jaitapur Village.[30] They can get Rs 400 – 500 per day for mollusks. Bigger mollusks can fetch Rs 200 per dozen! The mollusks cannot swim away from the construction or the expected hot water discharges. They will be destroyed.

Another section of the EIA of concern to many in the area of the proposed nuclear power plant is that regarding the “2 –D mathematical model studies” of the thermal dispersion of cooling water discharge into the sea from the six proposed reactors. The Central Water and Power Research Station in Pune carried out studies on behalf of NEERI and suggested to AREVA discharge tunnel lengths to ensure a maximum temperature rise of 7 ^{o}C at the point of discharge. Many local fishermen expressed concern whether a two dimensional model could capture the complexities of the sea, the currents, and the temperature profiles in the water. They also distrusted the scientists’ claims that a 7 ^{o}C rise in temperature would have no impact on the sea ecosystem. Many already had spoken with fishermen near the Tarapur Atomic Power Station, and heard of the decrease in catch from the fishermen there. Their own experiences on the water have taught them the conditions the fish prefer. They can read the clouds and the temperature, look at the water color, know where to put their nets and predict what kind of fish they will get.[31] A two dimensional model will not capture that. Nor does that model capture the seasonal variation in the catch. (The best fishing occurs December through March).

Without fishing, many fear the economy of the region will collapse. According to fishermen on the pier in Nate, most of the fishermen work for a daily wage, taking home between Rs 500 and 1000 per day.[32] They usually fish 20 days and 10 nights each month, but always take Fridays off (an important day for the Muslims in the village). Changes in the weather might change that. So too will changes in the availability of fish. The types of boats they own do not allow them to travel far out to sea or to remain out for long periods of time.

The EIA monitored the noise environment of the area—the "unwanted sound which interferes with various human activities and disturbs physical or mental peace."[33] Fishermen also expressed concern about the impact of the construction noise and lights on the fish.[34] Most of the construction materials will be transported to the site using big ships. The noise and lights from those ships will cause the fish to "go down"—they will not be available for the fishermen to catch in their nets.

If the fishermen do not bring home fish, they do not get their wages, they cannot buy tea or samosas or chocolate from the stalls on the pier. They cannot support the boat repairmen or the ice suppliers. Those men in turn will not be able to buy milk or mangoes. Everyone will suffer.

Until the announcement of the construction of the nuclear power plant, the people of the villages around the Jaitapur site felt secure in their lives and in their understandings of the world around them. The security has been replaced by fears that they will lose the only jobs for which they feel qualified. The taken-for-granted aspects of their lives can no longer be taken for granted. In addition, their knowledge of the land, of fish, and of the landscape has been challenged by researchers and scientists who might never have visited the area, have never seen their fishing grounds, and who have only superficial connections to any of it. The inability to convince the people at NEERI of the value of their local knowledge has left many villagers frustrated, bewildered, and angry. They are, after all, the ones who have experienced and who appreciate the place. And because of the attachments they have to the place, they have the most to lose if the proposed nuclear power plant upsets the natural systems. The local social systems already have been upset by the plans.

8.1.3 Lack of Open Communication

Not being heard by government officials and being excluded from the discussions and meaningful conversations about the proposed facility has also created psychological displacement for the people of the villages near Jaitapur. As indicated in Chapter 7, the NPCIL held few informational meetings in the local area to acquaint people with the project, talk to them about the potential impacts, or changes in plans. By law, NEERI should have published the EIA in Marathi so the local people could read it and understand. Instead, only extracts were distributed in Marathi and the full EIA was published only in English.[35] Villagers did not receive full information about the environmental impacts of the project. They could not ask meaningful questions or provide much feedback to officials. Still, the project received environmental clearance from the Ministry of Environment and Forests in 2010.[36] As a result, people have lost confidence in the government and its representatives at all levels.[37]

One of the lingering concerns about the project includes the amount of radiation that will be released on a regular basis and the potential for a catastrophic accident like that which occurred at Chernobyl.[38] The government tells them there are safe limits for radiation exposure.[39] On the other hand, activists have visited the area and shown the villagers photos of children born in the contaminated zones of Belarus—children with malformed limbs, scars from thyroid operations, and obvious learning disabilities. Villagers have heard about the problems of people living near other nuclear power plants in India (the Narora accident described earlier, for example) and some have visited Tarapur, also in Maharashtra. They worry it will be dangerous to live so close to the nuclear power plant.[40] They fear they too will get cancer and other illnesses and lose their businesses.[41] They fear that radiation will affect the future generations.

Some villagers also have heard about a 1.6 km "No Entry" zone around the plant and a 5 km "No Development" zone.[42] Where do those stop and start? How will they be enforced? Fishermen worry that security forces around the plant will prevent them from moving freely in and out of their port at Nate.[43] Some fear the Coast Guard or the Navy may curtail fishing in the vicinity of the nuclear power plant entirely. Without fishing, many of the villagers will lose everything. Unlike the farmers, they have no deeds to land. They will receive no compensation from the government if they cannot fish. Other fishermen already trawl the waters of the adjacent areas of the coast. The livelihood they learned from their fathers and have been teaching their sons will no longer be of much value.

The lack of complete information from government officials and the NPCIL about the Jaitapur Nuclear Power Project has led to feelings of insecurity about the future. The life they have chosen for the present is being threatened. The ties to the past generations of farmers and fishermen in their families will be broken. While they may still have possession of their houses, the many other emotional bonds, experiences, and feelings that make those houses into homes and "places" (in Tuan's sense of the word) are being broken, called into question, and upset. Change is in the air. The people of the Jaitapur area have been psychologically and emotionally displaced.

8.1.4 Displacement in the Planning Phase

Displacement during the Planning Phase of a nuclear technology project can involve the physical displacement of families who lose their homes and land to make way for the project, as occurred at Hanford. It can mean the loss of title to land and thus the ability to use that land for growing crops or grazing animals, as happened at Jaitapur. Displacement can mean the loss of access to land that had been part of traditional fishing and hunting grounds, as has been the case for the Wanapum and other Native Americans in eastern Washington. But displacement involves more than just the physical separation from a place. As explained in Chapter 3, when viewed more broadly, displacement affects individual and group identities, a person's emotional well-being, and the social networks they have developed to help them navigate through life. According to Cernea, displacement can be defined as socially caused disruption.[44] With the project still in its planning stages, the people near the Jaitapur site have already had their lives disrupted. They have lost their identities as farmers and worry about their futures as fishermen, fish transporters, and small businesspeople. The very foundations on which they built their lives are crumbling. While project officials maintain no one has been displaced by the project, using the more comprehensive definition of displacement, the people of Jaitapur have indeed been displaced.

Interestingly, whether at Hanford in the 1940s or at Jaitapur in the 2000s, those in charge of nuclear technology projects have turned to monetary compensation to serve as a palliative, reimburse people for their losses, and fix the problems being created. The U.S. Army, Indian government, NPCIL and others have tended to view the issues related to the Planning Phase as one part of economic, business transactions. However, money cannot adequately compensate for the loss of friendships, family ties, or social networks built up over decades. Money cannot replace a lifetime of learning how to understand the weather and water and patterns of fish behavior. As indicated by the Wanapum, money could not rebuild the sites they held sacred, their traditional hunting and fishing grounds, and seasonal gathering places. For many, money will never be an adequate substitute for the intangibles, the parts of life that cannot be commodified, that cannot be bought and sold in a marketplace.

Figure 8.5 People of Jaitapur, March 2015, Images by the Author

8.2 The Construction Phase

As touched upon in the previous chapters, the Construction Phase of a nuclear technology project requires bringing a lot of manpower to the site to clear away any existing structures, clear and grade the land, dig down to reach a firm foundation and accommodate the reactor core containment and piping for cooling water systems. In addition to management personnel, the workforce needed includes tractor, backhoe, and crane operators, pattern makers, concrete pourers, electricians, plumbers, machinists, steamfitters, pipefitters, metal workers, welders, and people who can measure, cut, hammer, screw, and assemble. Those skills usually cannot be found among the fishermen or farmers who live on the outskirts of the acquired land. Construction workers need to leave their homes behind to fill the temporary jobs at the nuclear technology site. Examples of the displacement caused by the Construction Phase of a nuclear technology project discussed below have been drawn from the construction of Hanford. Note however that the construction crews at Chernobyl faced similar conditions and recounted comparable experiences, as related in Chapter 6.

8.2.1 Living Conditions

Hanford's construction crews came from all over the United States, attracted by the prospect of jobs and above average pay (as recounted in Chapter 5). A large portion of the recruits came from the swath in the middle of the country, extending from Texas and Louisiana, through rolling lands of Arkansas, Missouri, the farmlands of Oklahoma and Kansas, and into Illinois and Wisconsin.[45] Most were unprepared for the isolated location or the primitive living conditions they found upon arrival in eastern Washington. The first obstacle to overcome: the barren foothills with winds that blew endlessly, rattling “screen doors, tarpaper roofs, and nerves alike.”[46] Early fur traders had written about the winds that blew topsoil around where the Columbia, Yakima, and Snake rivers met.[47] Years of plowing and dry land agriculture exacerbated the problem. By the 1940s, the dust storms were so severe some new recruits didn’t even last the night, choosing instead to return home on the next bus.[48] The storms soon got the nickname “termination winds.”

> I lived in a dormitory for a year after arriving here and I do remember the dust storms that we had during the summer. I recall one night I left the window open and I woke up in the morning with a big coat of dust all over everything. Dust was a big problem. With all the construction work and lack of trees, the ground was torn up and the least bit of wind would bring up what we call the Termination Winds. People would come here, take on the job, and not realize the weather conditions in this area. They’d work here for a while and everything was rosy until the wind would start to blow . . . They’d say ‘This is enough for me. I’m leaving,’ and they would terminate.
>
> Monty Straton[49]

Even when the winds stopped, the desert landscape of the Evergreen State surprised many: “. . . there was nothing farmlike (sic) or natural-looking about Hanford. The place was alienating, sterilized, lunar, an open air factory, curiously silent despite its great latent volatility.”[50]

DuPont chose the site of the former town of Hanford for Hanford Camp, the new home of the construction workers. Work began on Hanford Camp in March of 1943.[51] Unfortunately, getting the necessary toilets, fans, heaters, water heaters, and mess hall equipment proved more difficult than expected, delaying the completion of the facilities until October of 1944. Those delays made it even more difficult to attract skilled workers.

To compensate for what Hanford Camp lacked in creature comforts, DuPont spared little expense on food and entertainment. During a time when government rationing programs controlled the amount of meat, fish, cheese, butter, coffee, sugar, and canned, dried, and bottled foods allotted to each American family,[52] few of the construction workers complained about the plentiful food. Harry Petcher, who journeyed to Hanford to work in the mess halls, described the food program:

> We had what we called field messes. A lot of the box lunches were distributed out to the field messes for people who were way way out. I had from 20-30 refrigerated trucks running out into the areas delivering these box lunches. Most of them were picked up in the mess hall after breakfast. The mess halls made the coffee to go with them. Some mess halls made anywhere from 150 to 350 gallons of coffee a day. Everybody had a Thermos bottle. The bread was manufactured on the premises. We built another bake shop. They did pies and lots of different pastries, like dough-nuts and muffins. The food was very, very good.
>
> Basically, we had scrambled eggs, eggs up, pancakes, roast beef, chicken, fish. Most of our fish was fresh, it came out of Seattle. Salmon steaks, baked salmon. We had mashed potatoes, fresh because we were close to Moses Lake and Ephrata, the potato belt. We served a lot of beets from Utah. Most of the beef came from the Chicago-Omaha area. We served steak, not a lot of it, but we served it.
>
> It took them 10 minutes to eat a meal. The way it worked was, all this food was dished up by the cooks in great big bowls and platters. A table took care of 12 people. Two bowls of potatoes, two bowls of chicken, two bowls of whatever was served. The waiters came along pushing carts of food. As fast as one was emptied, there was another. You couldn't sit anywhere you wanted. You were sent to the first empty table. And there was no lingering over a second cup of coffee. We did have a little alcove at the ends of the mess halls where there were containers of coffee where a guy could fill his Thermos and take it to his barracks.
>
> The box lunch was like this, about 1,500 calories. We had three sandwiches with three ounces of food in each sandwich. Cheese, beef, or ham or chicken. There was fresh fruit, every once in a while we had

> salad. We used to give them a cold baked potato. A potato is a good vitamin source. Another thing, we dropped in two salt tablets in the box lunch. Toward the end, we started putting in candy bars, chewing gum and cigarettes, a sample pack of four. Our lunch cost was about 38 cents. We charged 55 cents.
>
> Harry Petcher, 1986 S.L. Sanger Bellevue WA

General Groves personally requisitioned one million pounds of meat and poultry just for the Christmas holiday celebration in 1943![53]

DuPont also strove to fill their worker's downtime—a bowling alley, two auditoriums/gymnasiums, and two theaters had been constructed at Hanford Camp. Bingo games, dances, and amateur theater productions filled those spaces.[54] But despite DuPont's best efforts, things did not always go smoothly.

> They built a big theater and big rec hall for our entertainment, and we had outdoor theaters; they weren't too good sometimes in wind storms in the outdoor theaters. You had to sit there with goggles on to watch a movie, but it was something to do.
>
> Lawrence Denton, Shipping Clerk[55]

> There was entertainment every night of the week. I think Monday was boxing, and Thursday, Friday and Saturday were name bands. But something every night. The theory being, you had those termination winds and people would quit by the thousands, some-thing was needed to keep them. You were 70 miles from anything.
>
> Those nights out there were wild and woolly, for a 22-year-old kid who had lived in Kansas all her life. They were an eye opener. Liquor was rationed but they always seemed to have it. The guys would pick up a can of Coke and go out to their car for a bottle. You drank it straight, and washed it down with Coke. Some of the bands were Henry King, Kay Kyser, and one not so well known, Tiny Hill. We also had Ted Weems and Jan Garber. They would play three nights and get paid off. Thousands would show up . . .

Jane Jones Hutchins, Secretary[56]

> We tried to control gambling. We wouldn't let any professional gambling set up. We had to let the poker and the dice games, you know, a group of guys wanted to shoot craps, we permitted it. We knew bootlegging was going on, and we knew where it was going on, but at that time booze was rationed, I think we got one fifth of bourbon every two weeks at the liquor store. A lot of these boys got legitimate liquor out of Chicago and they would bootleg it on the premises. I think it was common knowledge with the management and the military. They mainly wanted it kept under control.
>
> . . . In some cases, we would terminate lawbreakers, but in most cases it was important that we got them back to work. We needed workers.
>
> Robert "Bob" Bubenzer, Supervisor of Plant Protection, 1943 – 1945[57]

Still, Hanford was not home and, knowing the jobs would only last a year or two, construction workers had no reason to make it home, no reason to put down roots. Even the name "Hanford Camp" implied a lack of permanence. Men worked six days a week, ten hours a day. They lived in army-style barracks, each housing about 190 other men.[58] They relied on DuPont for transportation to and from Hanford Camp and the construction sites. Construction workers never developed intimate connections with or attachment to Hanford. Section 3.1.2 explains that sense of place emerges over time as people come to understand the cultural, historical, and social significances of a location. In a location like Hanford Camp, devoid of any past, lacking a cultural identity, and existing only to provide provisional housing, construction workers never developed a sense place. They continued to feel displaced.

8.2.2 Separateness

DuPont never expected to hire women to work at Hanford.[59] However, facing a labor shortage, the Army directed the company to expand its recruiting efforts. During the Construction Phase at Hanford, women made up 13% of the workforce, serving in the mess halls, as clerks, secretaries, nurses, and support workers.[60] A Supervisor of Women's Activities was hired to "promote stability on the urgent job" and provide a happy, safe, and constructive atmosphere for women.[61] That then translated into adding a housemother to each of the women's barracks and organizing weekly shopping trips to Pasco to break the monotony of life at Hanford Camp. Duties of the housemother included monitoring the activities of the barracks' residents.

> At the women's barracks, a guy would have to go in the gate, say who it was he wanted to see and the woman would be escorted down. At midnight or 1 o'clock, whenever the curfew was, they would scratch off names of men leaving the barracks, and if some names weren't scratched off, they would come looking for them.
>
> . . . we were living behind barbed wire at Hanford, all to protect womanhood. I know that where women were concerned, Hanford could either make you or break you. Gals who had never had male attention before were, you know, popular. You could either become a slut, I suppose, if you wanted to, or you could become very strong, and be able to say "No."
>
> Jane Jones Hutchins[62]

People of color also lived in fenced off, separate barracks. In this, the Hanford site followed U.S. Army practice and the prevailing Army policy that white men should not share facilities with people of color, believing such arrangements to be "fraught with danger to efficiency, discipline, and morale."[63] In 1940, people of color accounted for only 2.2% of the Washington population; by mid-1944, 16% of the workforce at Hanford consisted of Blacks and Mexican American laborers.[64]

> . . . one of the things that I couldn't understand . . . I'd never been around black people, and they had black people segregated from the whites. That didn't make sense to me. In the Christmas time when they—postal department was overloaded—they took us clerks and asked us if we would deliver mail. And I got the colored barracks and they still—confounded me more, why they segregated blacks and whites. But that was a fact and they accepted it and the whites accepted it.
>
> Lawrence Denton, Shipping Clerk[65]

Interestingly, racial segregation applied only to the barracks and not to the mess halls or to the recreation facilities. Cement finisher Luzell Johnson recalls working and eating shoulder to shoulder with white men.[66] Everyone played together on the baseball and basketball teams as well.

The one group never integrated into any activities at Hanford was the prisoners from McNeil Island, Washington. The U.S. government had acquired acres of apple, pear, peach, and cherry orchards along with the titles to the land for Hanford.

> . . . 1500 acres of producing orchards were in good condition and it was deemed necessary that they be retained. These 1500 acres would yield approximately 2000 tons of crops, all of which were considered valuable to the war effort when harvested. The average annual cost of maintaining one acre was approximately $250.00, representing a potential cost to the project of $375,000.00 per annum.[67]

Nine other orchards on the site were deemed to have among the finest fruit in the state. Rather than allow the original landowners to return and harvest their crops, or to have site employees undertake the task, DuPont and Colonel Matthias, entered into a contract with Federal Prison Industries of McNeil Island

> . . . to harvest the agricultural yield within the Project Area, including vegetables as well as fruits. The arrangement provided for the cultivation and preservation of orchards and agricultural products including necessary irrigation, spraying and pruning. The agreement also provided that Prison Industries take the entire yield to prison factories, and later make distributions to the Army and Navy and ship under Lend-Lease to Allied Nations.[68]

Construction began in 1943 on a separate camp for the prisoners, Columbia Camp, along the banks of the Yakima River. As at Hanford Camp, the men lived in tents until the completion of the barracks. They ate at a mess hall on the site—the food was delivered daily from McNeil Island, about 200 miles away. Water from the river had to be purified for drinking. The men had no indoor plumbing.[69] Much like the transportation system devised for the construction workers, buses shuttled prison workers to and from the orchards and fields each day. At the end of the 10-hour shifts, trucks from Prison Industries transported the fresh produce back to McNeil Island.

Unlike the farmers that had been displaced, the prisoners from McNeil Island (primarily conscientious objectors[70]) did not understand the crops, the weather, the landscape, or irrigation techniques. As the number of acres farmed decreased and the number of conscientious objectors dropped, the contract had to be renegotiated.[71] The operations closed down in 1947.[72]

For women, people of color, and the prison labor, forced segregation made it more difficult to overcome the displacement they already experienced. Even though some of it resulted from the paternalistic attitudes of DuPont—". . . a barricade fence was constructed to keep unauthorized personnel from entering . . ."[73]—or from societal attitudes of the time, or was brought upon the prisoners by their own actions, the separations prevented them from truly becoming part of the larger community around them.

8.2.3 Transition

By May 23, 1945, the Army had evacuated Hanford Camp; demolition began that same month.[74] DuPont laid off most construction workers. Some took jobs in Operations or other construction jobs on the site, some moved to western Washington to take jobs at Boeing or in the ports of Seattle or Tacoma, others returned home. Just like Wanapum and other Native Americans, the residents of White Bluffs and the town of Hanford before them, the residents of Hanford Camp were physically displaced to make way for another group who would occupy the space at Hanford. During the Operations Phase at Hanford, high profile physicists like Enrico Fermi and John Wheeler departed and white collar scientists and engineers migrated with their families to the newly built town of Richland. Blue collar workers, common laborers and their families found houses, trailer parks, shacks, tents, and hotels in Pasco and Kennewick.[75] Pasco also became home to people of color.[76] A new round of displacement in eastern Washington had begun.

8.3 The Operations Phase

The tens of thousands of tradesmen and builders brought in to erect massive buildings to contain the key nuclear technology processes get replaced by engineers and people specially trained to operate those facilities during the Operations Phase of a nuclear project. The types of people needed during operations might include chemists and chemical engineers to monitor radiation levels and identify changes in plant chemistry;[77] mechanical and electrical technicians to troubleshoot, test, and repair the complex mechanical or electric systems in the plant; instrument technicians to calibrate, test, modify, and inspect instruments and control systems; engineers to carry out reviews and analyses of data begin produced and projects under way on site; and various levels of licensed reactor operators responsible for starting and stopping reactor equipment, manipulating control rods, watching pressure and temperature gauges, maintaining data logs, and ensuring safe operation of the reactor at all times. For sites with no existing nuclear projects, all of these positions would need to be filled by people from other plants, other projects, other locations. That necessarily means displacing those people from their current jobs or hiring them out of college or technical programs and relocating them to the project site. This section discusses some of the displacement issues associated with the Operations Phase of the Hanford nuclear project.

8.3.1 Moving In

The people of Jaitapur worry that those hired to work at the nuclear power plant will bring with them a different way of life.[78] Coming from different regions of India, they will speak different languages. They will eat different foods, wear different costumes, celebrate different festivals, and cling to different cultural traditions. Those differences will cause conflict between the locals and the "colonists." Because the U.S. government had evicted the residents of the Hanford site and the town of Richland, the new residents and employees arrived in a place where the past had been bulldozed down and replaced by thick, boxy, concrete structures that held within them the power of the atom. The future of Hanford and Richland was theirs to make.

For most of the people employed in Operations at Hanford, the choice to leave behind routine of their old lives, to wave good-bye to their families and friends, to start again in the deserts of eastern Washington was a voluntary choice, a voluntary form of disruption to place attachment (See Section 3.2).[79] Even though they had time to prepare for the change and most did bring their families with them, and although they could surround themselves with knickknacks that reminded them of "home," the new arrivals at Hanford faced their own difficulties adjusting to their new lives. As Herb Depke recalled,

> Mother and I took the train from Chicago to Spokane, Washington. Dad and the Dosses drove to Spokane and picked us up. They took us back to Richland . . . We got to Richland and immediately encountered a dust storm. That is my first memory of Richland, a tremendous dust storm. You could not even see your hand in front of your face. We stopped at the grocery store on the way to our new home. I got out the car and walked to the grocery store. I went right straight into a fence and gave myself a bloody nose.[80]

Van and Di VanWyck arrived from Charleston, West Virginia. They found the open desert refreshing after the damp, dirty, chemical-laden area around Charleston. A strike at the Seattle lumber yard delayed the completion of the duplex house they had hoped to occupy, so they opted for a pre-fabricated house instead. The $37.50 per month rent included grass seed to start a lawn to try to tame the ever-present dust. However,

> [i]t happened that we had a faulty pre-fab. It had some construction problems they tried to repair. I came home one day and there was a man under the house in the middle of a terrible windstorm. I asked him what he was doing and he said he was trying to get this house fixed so it won't blow away. "We lost two of them last night," he said. We moved into another house.

Di VanWyck[81]

In contrast, Opal and Frank Drum, who had spent their early years living with two daughters in an 18 foot long trailer, stayed for 14 years in their brand new "pre-fab" before renting half a duplex from friends from Nebraska.[82] In all, 1,800 pre-fab houses went up in Richland.[83]

Like the construction workers before them, operations employees came from across the country. Scientists and engineers moved west from the University of Chicago, from the Oak Ridge facility in Tennessee, from DuPont locations in Delaware, Pennsylvania, Alabama, Colorado, and elsewhere. They arrived in Richland and at Hanford as outsiders—they did not yet appreciate the desert landscape or have social networks of which they were a part. In fact, there were no community groups, no church organizations, no social clubs for them to join—both the hard structure and the social structure of the area had to be created from scratch. That took time and effort.

> When I got here in '43, everything was torn up, Richland was torn up real bad. They were building every place, the houses, the roads, putting in all the different systems, the church was done, the Catholic church, a couple of the other churches were about finished. And the old Kadlec hospital was about finished. The streets weren't completed yet. We had a cafeteria across from where the federal building is now, and that's where we all ate. If you didn't want to eat there, you could go to Kennewick and eat at some cafe.
>
> Jerry Saucier, Reactor Operator[84]

> . . . there was a young man who was an engineer and he was real interested in amateur theater. We were trying to get the theater off the ground. My husband had been given carte blanche. This was the type of thing he did. He tried to arrange church, activities for people

> because they knew they weren't going to keep these people, out of college, and we were sort of a stratified group.
>
> Most of us were from the same social background. Everybody had been to college in that particular group. So DuPont or Remington Arms [a DuPont subsidiary] said, 'Do what you can do, and we will underwrite it, anything you can do, to get these people some recreation around here.'
>
> Betsy Stuart, Secretary[85]

The Richland Singing Cops, a barbershop quartet made up of patrolmen working for DuPont, and the Richland Village Players theater troupe first appeared in 1944.[86] Father William J. Sweeney said the first mass in Richlands first Catholic Church, built to seat 613, but overflowed with over 1,000 for midnight mass.[87] The only other church in town, the United Protestant Church (a merged congregation of 17 different religions) also opened its doors that December 24.[88]

Villagers, Inc., a nonprofit, began publishing a weekly newspaper, with the first edition delivered to all residents on March 8, 1945. The Richland Junior Chamber of Commerce (Jaycees) organized softball leagues in the summer of 1945. That year also witnessed the opening of the city library and the start of the annual Richland Days parades—later called Atomic Frontier Days-- featuring floats, celebrities, and the crowning of a beauty queen and her court. The Richland Symphony played its first concert in 1946. Over time, civic clubs—the Rotary Club, Lions Club, Toastmasters, League of Women Voters, Masons, Kiwanis Club, and Boy Scouts of America—established branches in Richland. Even dogs and cats tried to make Richland home.

> One day [Liz] went to call on someone who had visited their church. There was a friendly Great Dane in the yard and when she knocked on the door, he came and stood patiently beside her. When the lady of the

> house invited her in, the gigantic dog walked in the house with her. He went in the kitchen area and curled up in the smallest area as a Great Dane can curl up in. After the visit, Liz started to leave and the owner of the house said don't forget your dog. Liz's reply was, that's not my dog; I thought he was your dog. Well, they shooed the dog outside and he wandered down the street until he came to his own home . . . I expect the dog knew his house, he just wanted to meet the neighbors.
>
> Donna Jackson[89]

Until the new Richlanders could recreate the types of social structures they had known before coming west, until they could re-establish routines and become involved in institutions that brought meaning to their everyday activities, they remained disconnected and unsettled. Slowly, they began to make friends, form memories, and develop a sense of place—a sense of being at home and belonging.

8.3.2 Changing Times

As indicated in Chapter 5, the end of World War II brought changes to Hanford and to Richland. Not only was there a shift from war time to peace time operations, but there was a shift in management at the very top: General Electric (GE) assumed management control of Hanford from the highly paternalistic DuPont in September, 1946 and the U.S. Army ceded control to the newly formed Atomic Energy Commission (U.S. AEC) as of January 1, 1947. Whereas the Army had decades of experience overseeing large-scale operations, U.S. AEC officials came to their jobs with a different type of background. For example, David Lilienthal, its first Chairman, had trained in utility law, had served on the board of directors of the Tennessee Valley Authority, and had advised President Truman on the matter of atomic weapons.[90] The new leaders of the U.S. AEC also quickly realized that although they had been given the task of developing peace-time uses of the atom, their assets consisted of facilities and materials devoted to the development of atomic weapons, and not to research into the full range of uses of the atom.[91] The U.S. AEC did choose to continue the practice of using private contractors to operate the nuclear technology facilities, leaving GE in place at Hanford.[92]

With knowledge of the Soviet possession of an atomic bomb and, later, growing tensions in Korea, production again increased at Hanford. New rounds of construction also began. In 1946, Hanford Operations employed almost 4,480 people and Construction only 140. Within two years those numbers had jumped to about 8,630 in Operations and just over 14,670 in Construction.[93] The new construction workers lived in the hastily constructed camp in North Richland (as described in Chapter 5) or found accommodations in Kennewick or Pasco.

As early as 1948, the U.S. AEC and GE had developed a new Master Plan for Richland.[94] That plan included replacing government operated businesses with privately owned ones and selling all the government owned "ABC" houses to the public. As of April 1, 1948 the homes in Richland were rented <u>un</u>furnished.[95] Residents had the option of purchasing the furniture or shopping for their own replacement items. The town's first privately owned and operated retail store, Richland Electric Appliance and Furniture, opened later that year.[96] Clothing and sporting goods stores, a food market, and a Studebaker car dealership followed. Even so, GE accountants had the final say as to which stores opened in which locations.[97]

The League of Women Voters set out to educate the community about the possibilities facing them as an independent town. The Chamber of Commerce voted in favor of private ownership. Some residents argued that the government owed them something for the sacrifices they had made.[98] Others wanted to join the wave of home ownership that was sweeping the country. However, when the Chamber of Commerce conducted opinion polls of local residents to gauge their sentiments, the resident of Richland did not track with the rest of the nation. In March 1955, 73% voted against a property disposal program and 56% voted against self-government for Richland.[99] Respondents wanted to continue the life they had come to know and appreciate. Then, on August 4, 1955, the U.S. Congress passed Public Law 221, "An Act to Facilitate the Establishment of Local Self-government at the Communities of Oak Ridge, Tennessee, and Richland, Washington, and to Provide for the Disposal of Federally Owned Properties of Such Communities."[100] That legislation provided guidelines for appraising property, transferring titles, prioritizing the sale of properties, setting up financing, ensuring continued residence in Richland by certain categories of occupants, and even allotted funds to cover contingencies that might arise in the transfer of municipal services to local entities. Public Law 221 thrust Richland residents into another phase of uncertainty and disruption.

> . . . they [the U.S. AEC] were going to get out of the business of having houses, and a lot of the people were pretty leery. Hey, they're going to be shutting this down because most of them knew, oh yeah, we've got plenty of weapons. We really don't need all this plutonium for weapons. And so some people were very hesitant. They offered the homes at 75% of the appraised value of the house if you didn't want the buy-back clause. And if you paid full price, the government would promise to buy it back if something would happen that there was a real economic downturn in Richland. And I found this one guy who says, he was in no way ever going to invest in his buying a house in Richland. And I said, okay. A ranch house is appraised at $10,000, if you buy one, I'll pay you $8,500 for it. So it's appraised at $10,000, and I said, I'd pay you at $8,500. And you buy them in the no buy-back clause, and so that's how I bought my first house.
>
> Emil Leitz, Engineer, Research and Development[101]

It took two decades for Richland to be completely turned over to its residents.[102] During those years, the fortunes of the Hanford sites waxed and waned as residents predicted (See Table 5.3). Contracts between the U.S. AEC and private companies expired. New contractors took the place of the old ones. Sam Moore recalled that "seemed like every time you'd turn around, [contracts] were turned over to somebody new."[103] In an era when lifetime employment with one company tended to be the norm, families were forced to decide between relocating to stay with a company, and changing employers to remain in eastern Washington. The low crime rate in Richland, the age of any children they had, and the wide open spaces to which many had grown accustomed influenced many of the decisions.

> And some of us stuck it out, like myself. And I worked for ten years for GE and then GE pulled out. And that's something that really irritates me to this day because--I don't know if--you probably don't want to televise this, but anyway, I think that was timed. The government always has these contractors come in and then they change. And I was—they had a ten year contract to be vested. But they had an age clause. You had to be 28 years old and I was a one month away from that. So I either had to go back east and work for GE back there—but I had a family of four now. And of course I didn't want to go back there and leave my family here. So I didn't get vested. And then different companies come. And Westinghouse, and on, and on. And every time I really had a nice job—I really loved it--a different company would come in. I had to change companies or I had to change jobs. I finally got tired of it and I quit. And I started my own business.
>
> Leroy Noga, Instrumentation[104]

On the one hand, families had established ties to Richland and the region. They had built their "Atomic City" out of nothing and were not eager to leave. It finally had become their "place". On the other hand, disruption and displacement continued as employees at Hanford faced uncertainties about how long their jobs would last, whether contracts would be renewed, and what would become of Richland if facilities at Hanford did begin to close.

8.3.3 Secrecy

During World War II, fears of the enemy obtaining the secrets to making atomic bombs compelled the Army and DuPont to develop tight security measures at Hanford and in Richland. DuPont covered security for the operations side of the business, running background checks on all employees, giving clearances to personnel to work in particular areas of the site, patrolling the site, even performing maintenance on the homes of the DuPont employees in Richland.[105] The military covered the outer perimeter of the site, monitored phone calls, and, in the 1950s, protected Hanford from air attacks. Most employees did not question the need to keep secrets about what they were producing or how much during World War II or even as the Cold War took hold thereafter. What they did not know to question were the secrets about radiation releases that occurred at Hanford for decades.

The termination winds that newcomers to the area complained about so vehemently had been expected to help disperse radiation from the processing plants at Hanford.[106] Instead, the winds often deposited radioactive materials on the crops and the people around the site. It then became policy only to schedule the release of emissions when wind conditions were most favorable for dispersion.[107] That plan fell by the way-side when production pressures mounted.[108] The two chemical separation facilities also did continue to release significant quantities of fission products until filters were installed in 1950.[109]

DuPont, GE, and the other contractors at Hanford hired Health physicists to oversee the monitoring of radiation received by employees across the site.[110] According to Gosling and Fehner, ". . . health physicists made a concerted effort to shield radiation sources, instill careful work habits, scrutinize workplaces, and screen workers to detect early signs of damage."[111] They made sure no employee took any radiation home with them. If any radiation was detected on the skin, the individual had to be scrubbed and cleaned until no traces showed on the dosimeters. If traces of radiation appeared on clothing, those clothes would be buried or burned on site. Radiation monitors even surveyed the homes in Richland to detect any stray specks of radiation. Detections there would result in checking the bus the employee had ridden on as well as the furniture, rugs, and clothes in the home.[112]

> Health physicists tracked and kept records of the amount of exposure for each employee—usually based on the film badges (sometimes called "pencils") they wore each day to work. [B]efore the end of the year was out, if you were running short of exposure, then they would transfer people--particularly the radiation monitors--to different areas . . . and letting their people cool down a little bit. It was just a way of equalizing the dose rates to the personnel. And it worked good in theory.
>
> Bill Tyler, Health Physicist[113]

The health physicists dealt with the exposure, with doses of radiation received, but not with the levels at which those doses might become dangerous.[114] Nor did they deal with any of the potential human health consequences of that exposure or those doses, even though the scientists who had helped establish the Manhattan Project in the 1940s had been well aware that some of their own colleagues had died from exposure to the materials they were studying.[115] In addition, as explained succinctly by Paul Loeb,

> There [were] two different levels of Hanford risk-taking. Being bombarded with gamma rays while spending your dosimeter-measured half hour in a hot zone [was] different from handling radioactive materials with tools and procedures that supposedly protect[ed] you from all exposure. The first situation demand[ed] faith both in the harmlessness of doses beneath the allowable threshold and in the stability of official threshold limits which have dropped from almost one REM a week in 1934 to fifteen a year in 1950 and five a year since 1957; the second requires only that containers, glove boxes and general mechanical systems will maintain their integrity.[116]

Hanford workers put their faith in both the allowable thresholds and in the equipment they worked with on a daily basis. They also put their faith in the health physicists. They trusted that the measurements taken were accurate, that they would be told if they had reached or exceeded their allowable limits. Robert Colley recounts the story of one spill he cleaned up:

> . . . we were allowed an hour. We were in 1,000 R dose rate. And we were allowed an hour. And we took 100 R. And we were only supposed to take a little bit each day. But it was classified at that time. And no one ever knew how much--except we knew, and the health physics people knew. And we took, in less than an hour, we took 100 R—body. And that's many years of working out there. You normally took three R a year—a whole year.
>
> And we took 100 R in less than an hour. But no one was left in the building, and we were very fortunate. Everything that would run was still running. And then they would come into help shut it down and get things cleaned up again . . . But there was three of us, and the other two boys are all gone. I was the oldest out of the bunch, but they died young. We never knew for sure whether we would--I never felt anything from 100 R. I didn't feel head-ache-y or sick or anything. And they allowed me to come back to work the next day.

> But that was all classified at that time. And nobody--they got it okayed from someplace. But I never had any ill effects from it. I took my maximums every year in all those years, and never had any ill effects that I knew of.[117]

For Colley and others at Hanford, it would be important to understand not just the doses to which they had been exposed, but the particular isotopes involved and their half-lives. However, the compartmentalization that begun during World War II continued. That information remained classified.

Table 8.1 below outlines the standards for radiation exposure over the years as established by the International Committee for Radiological Protection, the National Council on Radiation Protection and Measurements, the U.S. AEC and DOE, and as set at Hanford.[118] In the early years, radiation limits were established by a measuring individual's exposure (radiation absorbed dose or rad). Later standards took into account the impact of exposure and the type of radiation (alpha, gamma, beta), recognizing that the different impacts each had on the body. Thus, later standards appear in rem units (Roentgen equivalent man). As more information became available about the impacts of radiation on human health, standards tightened. As can be seen from the data in the table, the limits set for Hanford employees remained at or below the standards set by all governing bodies.

Table 8.1 Radiation Exposure Guidelines

Year	International Committee for Radiological Protection	National Council on Radiation Protection and Measurements	U.S. AEC/DOE	Hanford Radiation Protection Guidance
1945	n/a	n/a	n/a	gamma: 0.1 Roentgen/d; beta: 0.1 rep/d (Roentgen Equivalent Physical dose)
1947	0.2 rad/day, or 1.0 rad/wk	0.1 rad/day, or 0.5 rad/wk	0.1 rad/day	n/a
1949	0.2 rad/day, or 1.0 rad/wk	0.3 rad/wk	0.1 rad/day	as above
1950	0.3 rad/wk	0.3 rad/wk	0.3 rad/wk, or 3.9 rad/13 wk	n/a
1954	0.3 rad/wk	0.3 rad/wk, or 3.0 rad/13 wk, or 15 rem/yr	0.3 rad/wk max, or 3.0 rad/13 wk or 15 rem/yr	gamma: 3 Roentgen/year
1957	0.3 rad/wk	5 rem/ yr average and 12 rem/yr max	0.3 rad/wk max, or 3.0 rad/13 wk, or 15 rem/yr	n/a
1958	0.1 rem/wk, or 3.0 rem/13 wk	0.3 rem/wk, 3 rem/13 wk, 12 rem/yr max	0.3 rem/wk max, or 3.0 rem/13 wk, or 12 rem/yr	n/a
1960	0.1 rem/wk, or 3.0 rem/13 wk	0.3 rem/wk, 3 rem/13 wk, 12 rem/yr	3.0 rem/13 wk, 5 rem/yr average	Total: 5 rem/yr; gamma: 3 Roentgen/yr
1963	n/a	n/a	n/a	Prospective: 3 rem/qtr, 5 rem/yr
1965	3 rem/13 wk, 5 rem/yr	0.3 rem/wk, 3 rem/13 wk, 12 rem/yr	3.0 rem/13 wk, 5 rem/yr average	n/a
1971	3 rem/13 wk, 5 rem/yr	3 rem/13 wk, 5 rem/yr	3 rem/13 wk, 5 rem/yr	n/a
1974	3 rem/13 wk, 5 rem/yr	3 rem/13 wk, 5 rem/yr	3 rem/13 wk, 5 rem/yr	n/a

For newer workers, the disconnect between radiation exposure and its consequences led to a cavalier attitude. Some employees removed their protective gear because it was hot and restricting.[119] For others, finding excess radiation on articles of clothing became routine—"no biggie."[120]

In the 1960s, Health Physics Journals published information about the impact of radioactive iodine releases from Hanford on the human thyroid.[121] By the 1970s research into the links between radiation exposure at Hanford and cancer also began to appear in journals.[122] Then, in February of 1986, the U.S. Department of Energy released 19,000 pages of information detailing the amount of radioactive material released from Hanford since it started operations.[123] Over the next five years, another 50,000 pages of material about the Hanford operations became public information. Paraphrasing Loeb, the circle of silence had made it easy not to question.[124] That was no longer the case. Hanford employees, retirees, family members, friends, neighbors, and residents of Washington, Oregon, and Idaho slowly came to grips with the reality of the radiation releases from and contamination of Hanford.

For those who believed that nuclear power was safe, that technological advances would solve problems faced in the present, and that there are indeed acceptable doses of radiation to which people can be exposed without risk, nothing changed. For those who witnessed their relatives die of leukemia or cancer after spending their careers at Hanford,[125] or for local farm families who had eaten their produce and drunk the milk of their cows and goats all those years, the new knowledge disrupted lives and forced them to begin to question the events of the 40 years that had passed.[126] The feelings of trust were shaken, and the way that people looked at the lands, now revealed to be tainted by toxins, were changed forever.

"Who would want to believe that in the name of stopping the Evil Russian Empire from swallowing us up, companies, under contract with our own government, would poison all of us, without at least giving us a chance to get out of town?"[127] Without their knowledge, these people too had been displaced.

8.4 The Legacy Phase

As shown in Figure 8.1, the Legacy Phase constitutes the final phase of a nuclear technology project. When a power company decides to close a nuclear power plant that has been producing electricity for the duration of its operating license, it begins decommissioning the facility. In the United States, decommissioning must occur within 60 years of the plant's ceasing operations. Closed plants have three options:[128]

1. Immediate dismantling, which implies facilities are taken down, and structures and devices contaminated with radioactivity are removed or decontaminated to levels that permit the release of property;
2. Deferred dismantling, which occurs when the facility is maintained and monitored to allow radioactive decay to occur on site. After a period of time, the facility will be dismantled, the radioactive material removed, and the property will be decontaminated;
3. Entombment, which permanently encases the site and its radioactive contaminants in a material such as concrete until radioactive materials have decayed away.

As of this writing only three reactor units in the United States have been approved for immediate dismantling. Because a long-term storage site for radioactive waste does not yet exist, another 12 have transitioned from operations to deferred dismantling and five have had their licenses changed to indicate that spent fuel storage is the only nuclear technology activity being carried out at the site.[129] For example, at

Dresden 1 in Illinois, shut down in 1978, site restoration will occur in 2036. Vermont Yankee, which ceased operating in 2014, should complete decommissioning by 2074. Until then, the sites remain off-limits to all but those involved in the removal of the massive amounts of concrete, wiring, piping, pumps, steel and other metals brought to the site for construction; inspections of the site; and attempts to remediate the site or prepare it for other uses.

In those cases, things usually have gone as planned, or fairly close to plan. In the case of Hanford, with its early war-time history and subsequent additions of nuclear reactors and test facilities, there was no standard decommissioning plan. Local and state politicians worked diligently over the years to continue to bring projects to the site: The dual purpose N reactor, the Fast Flux Test Facility (FFTF), and a commercial power reactor under the Washington Public Power Supply System. Although the commercial reactor still sends electricity to the grid in the Pacific Northwest, the N reactor closed in 1987 and the DOE decided not to continue work at the FFTF in 1993.[130] The U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology signed the Tri-Party Agreement in 1989 to clean up the site. For the Chernobyl Nuclear Power Plant, the catastrophic accident put an end to any plans for the operation and eventual decommissioning of that site. This section uses those two examples to illustrate the displacement that can occur during the Legacy Phase of a nuclear technology project.

8.4.1 Hanford's Legacy

8.4.1.1 Ceased Operations

> [W]hen the edict came out that we were going to phase out and clean up, one of the first facilities--well I think it was the first facility—that

> we started tearing down was Semi Works . . . we shut it all down and demolished the building and just imploded it in place. Built a dirt berm over it, cleaned it up. Most of the cells and the tanks are still in place, but they're full of grout. And then there's concrete over it. And what we did was tear down—this was approximately a three-story building with three stories underground. So when we tore down the building—it had a lot of piping and columns—we tore down the building and left the west wall standing. And we filled everything we could get inside like the basement and concreted it in place. And then we undercut the west wall. And this is probably four foot thick. And got a couple of Caterpillars and chains and hooked it over the top of the west wall. Pulled it down over like a lid. And then dirt berm over it, and there it is.
>
> Bill Tyler, Health Physics Technician[131]

Unlike conventional commercial reactor sites that may be home to up to six reactors, nine water cooled reactors and support buildings were constructed in Hanford’s 100 Area along the Columbia River to support plutonium production. The 200 Area on the central plateau housed the chemical separation and plutonium refining facilities. The buildings in the 300 Area included laboratories focused on weapons and fuel fabrication research. All of these structures and many more have become part of the massive decontamination, decommissioning, and clean-up efforts at Hanford (See Figure 8.6). The 1989 Tri-Party agreement estimated the clean-up would take 50 years at a cost of about $100 billion.[132] The 2015 estimate reached $110.2 billion with most of the work completed by 2060.[133]

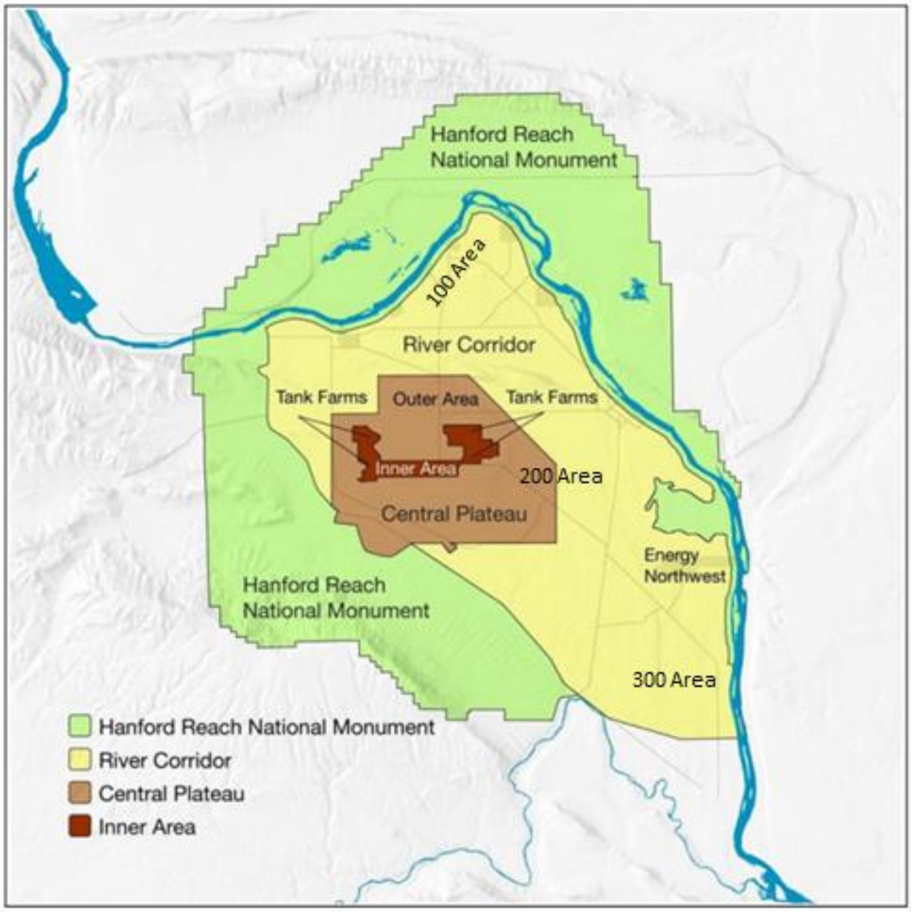

Figure 8.6 Focus of Clean-up Efforts at Hanford[134]

It must be remembered that when DuPont and GE constructed many of the facilities at Hanford, no standards existed for how to dispose of the wastes from nuclear facilities. Their employees borrowed standards from the petroleum industry, the steel mill and blast furnace industries, and commercial landfills operating at the time. Prior to the 1960s, those standards emphasized minimizing personnel exposure to waste and preventing the spread of radioactivity throughout the site, but few guidelines had been written for separating different types of waste or how to package it.[135] The first waste disposal guidelines emerged in the late 1960s.[136] Those specified that liquids be packaged with inert absorbent materials and that organic matter be sealed in plastic and buried in wooden or metal containers. By the 1970s, the U.S. AEC had released its regulations for the segregation of transuranic wastes (artificially made radioactive elements like plutonium and americium). Throughout the 1970s and 1980s the regulations surrounding the disposal of low-level and high-level radioactive wastes became increasingly specific, restricting the types of containers, their contents, and even the materials lining the pits into which they would be placed.[137] Unfortunately, many of those standards and regulations came too late to affect the waste already poured into the ground or buried at Hanford.

As a result, as mentioned in Chapter 5, 75 solid waste burial grounds dot the Hanford grounds. One of those contains the ambulance that carried Harold McCluskey from the plutonium finishing plant to the hospital after his glove box exploded and contaminated him with 500 times the allowable dose of americium 241.[138] Another burial ground houses the rail car containing remains of animals used in war-time examinations of the impacts of radioactivity on flora and fauna.[139] Still others contain the rail cars used to haul irradiated fuel from the reactors along the Columbia River to the separation facilities about 10 miles away,[140] or rotting wooden boxes filled with "hot" (radioactive) waste from the one of those separation facilities, the PUREX plant.

> And I recall one big one that had enough lumber in it to build two B houses. Huge—it sat on two flat cars. And we put it in, and we took readings over the top of the tunnel as it went out of the tunnel towards the burial ground. And it read greater than 500 R. And as you know, 500 R for an hour is a lethal dose rate to 50% of the people, 60%.
>
> Bill Tyler[141]

In addition to the solid wastes burial grounds and about 1,000 locations around the site where the soil has been contaminated,[142] 56 million gallons of liquid or semi-liquid wastes remain stored in single-and double-walled storage tanks. Underground plumes from those tanks, reverse wells, ponds, trenches, and French drains contain radioactive tritium, iodine 129, strontium 90, and chromium that inch toward the Columbia River.[143] Vitrification has been explored at Hanford since the 1960s as a means of handling some of those wastes.

> . . . I spent three or four months with them learning about vitrification and also something called calcining, where you take liquid waste and heat it up, and drive off a lot of the volatile materials and turn it into a powder. And then from that, we would melt it, vitrify it, make glasses.

They also demonstrated the process for borosilicate glass using an in-can melter:

> . . . we sprayed liquid waste into the spray calciner, which is heated to about 700 degrees centigrade. And as the droplets came down, they dried. And it would be hot enough to where you'd get rid of all the nitrates and convert it to oxides. And the oxides would then fall down into the melter.
>
> . . . we would add additives, boron and silica, to the calcine, and then heat them up to over 1,000 degrees centigrade in either the melter or the in-can melter and convert to the glass.[144]

When President Carter enacted a moratorium on reprocessing spent nuclear fuel, the vitrification research at Hanford came to an end. The Department of Defense did pick up the research stream; it formed the basis of the technology now in use at the Savannah River site in South Carolina.[145] Vitrificaton will form much of the liquid waste into glass bricks that can then be stored without fear of the radioactive waste seeping into the water table. Yet, as mentioned in Chapter 5, Bechtel has yet to complete a commercial scale vitrification facility at Hanford. In March 2016, a U.S. District Judge Rosanna Malouf Peterson issued the new deadlines for the vitrification project. The plant to convert the high level radioactive waste into glass must be fully operational by 2036.[146] The project then faces its next hurdle: Those bricks will need to be warehoused until they no longer pose a danger to humans or the environment—where will they be stored?

Many of the engineers, scientists, reactor operators, and other personnel hired in the 1940s, 1950s, 1960s, and 1970s retired over the years. When younger employees found their careers ending at Hanford, they found jobs at Pacific Northwest National Laboratory, a Department of Energy research facility in Richland. Some sought positions with the Nuclear Regulatory Commission, at other reactor sites across the country, in academia, or in various manufacturing industries. Just as they had displaced the construction workers before them, they had to move out to make way for the new type of workers at Hanford.

8.4.1.2 Altered Lives

As Hanford's operations wound down, concerns over the impacts of the emissions escalated. The release in 1986 of thousands of pages of documents detailing the release of radioactive elements into the air and water by contractors at Hanford led to lawsuits filed on behalf of about 5,000 plaintiffs who had suffered, primarily from thyroid diseases.[147] Deborah Clark came into the world in 1949 just two weeks after the Green Run experiment and was raised on bottled raw milk from a farm in Oregon, directly south of Hanford.[148] She died in hospice care awaiting her chance to have her case heard by a judge. "I get so angry. The government has recently bailed out big banks and corporations, and they could care less about these poor people," said her lawyer in 2011.[149] Over the years, many questioned the manner in which the government reconstructed their doses of radiation.[150] Others questioned why illnesses resulting from doses under a certain threshold level were excluded from consideration, or why those with thyroid cancer might receive compensation but not anyone with other forms of thyroid disease.[151] "I think they're just waiting for all of us to die," claimed thyroid cancer survivor Jackie O'Neil.[152] After 24 years of legal wrangling, the final plaintiffs in the cases reached agreements in October 2015. Because the government indemnified the contractors (DuPont, GE, UNC Nuclear Industries and others), the U.S. Department of Energy (and U.S. taxpayers) was left responsible for the legal fees.[153] Although no final sum was revealed, it was estimated in 2009 that $57 million had been spent by the defense lawyers by that time.[154] Plaintiffs' attorneys wondered, "Might that money have been better spent helping people with their medical bills instead?"[155]

The drawn out legal cases left many feeling betrayed and angry. Just as the people near Jaitapur have been reduced to counts in categories in the Environmental Impact Assessment (Literates/Non-literates, Main workers/Marginal Workers/Non-workers, and so on) during the Planning Phase,[156] people with illnesses had been reduced to exposure limits and estimated doses—to numbers. They received no empathy for their years of pain and suffering, no understanding of the years of uncertainty about the course their illnesses might take or what their futures might hold. Their lives were interrupted and disrupted. According to one juror, they had ". . . been wronged twice—by Hanford and now by the court."[157]

Groups of clean-up workers at Hanford also have expressed concerns about exposures. In particular, workers in the tank farms in the 200 Area have reported chronic and acute breathing issues after being exposed to the vapors emanating from the waste storage tanks. A 2004 report from the National Institute for Occupational Safety and Health (NIOSH) recommended that the contractor (CH2M Hill Hanford Group, Inc.) do a better job of monitoring the air quality, provide its employees with air purifying respirators, and track their exposure and health conditions on a regular basis.[158] The Office of Independent Oversight and Performance Assurance (OA) of the Department of Energy conducted an independent review into allegations of inadequate worker protection at the tank farms that same year.[159] Although a panel of 23 reviewers appreciated CH2M Hill's efforts to understand the issues behind the vapor issue and to better communicate with their employees, they did conclude that the company kept insufficient personal vapor exposure data, inadequate direct-reading instrument and personal exposure records, some of the instruments used could not detect the vapors they were intended to record, safety controls were not sufficiently rigorous, and that many issues identified in the past had not been corrected.[160] Like the NIOSH report, the OA report recommended personal protective equipment be issued to employees. Yet more than a decade later, the issue of providing adequate protection to the workers cleaning up the tank farms at Hanford remains in the headlines. Diana Gegg drove heavy equipment at Hanford until she was enveloped in a vapor cloud in 2007.[161] She developed flu-like symptoms, vision problems, and eventually had to stop driving. Her diagnosis: toxic encephalopathy and neurotoxicity. "My life ended that day as I knew it," she said. Dave Klug recalls walking into the control room at the tank farm in January, 2010: "Immediately, I had tightness in my chest. I lost feeling in my face. My heart rate was going crazy." He was off work for 11 months and now has reactive airway disease and occupational asthma.[162] While not everyone gets sick, many do have respiratory problems, bloody noses, and throat irritations. A coalition of labor unions called a work stoppage in July 2016 to demand bottled air for those working at sites containing either the single- or double-walled tanks.[163] Later that month the Washington Attorney General asked a federal judge for immediate protection for workers at the tank farms.[164] The battle for safe working conditions for those toiling to clean up the waste left at Hanford continues. In the meantime, those suffering the debilitating effects of inhaling the toxic vapors from the tank farms fight just to breathe.

Like those exposed to radioactive emissions from Hanford's reactors, the clean-up workers who breathed vapors from the tanks farms have witnessed their lives change almost overnight.

> It shouldn't have happened to me. It shouldn't be happening to anybody.
>
> I've just been fighting. Getting worse, getting better, getting worse, getting better, to the point where I thought I was dying. When you can't breathe and every day you fight just to get air, it's one of the worst experiences. I'd give up an arm; I'd give up a leg to be able to breathe.
>
> Seth Ellingsworth, 35-year-old Hanford Worker[165]

Many can no longer hold jobs. They have lost that security and day-to-day continuity. They try to get compensation for their medical bills. However, even when doctors have concluded that there is no other plausible explanation for their illnesses than the concentration of heavy metals in their systems, and that there is no source of those toxins other than their work at Hanford, the Department of Labor has denied their claims under the Occupational Illness Compensation Program.[166] They are being shut out and excluded. They have been emotionally, psychologically, and physically displaced. "It ain't right, it ain't right."[167]

8.4.1.3 What Next?

Except for public tours of selected sites now being offered through the Manhattan Project National Historic Park and the U.S. Department of Energy, Hanford remains off-limits to everyone except those working on clean-up projects. Following the clean-up of the site, the land will be placed into long term stewardship, which includes monitoring and maintenance to ensure that the environmental and human health remain protected.[168] At some point in the future, areas closest to the city of Richland may return to industrial uses and Native Americans may be allowed to return to their traditional trading, fishing and hunting grounds. Until that time, however, barbed wire fences (Figure 8.7), concrete barricades, and "No Trespassing" signs keep unwanted visitors out. The activities that occurred at Hanford over the decades have displaced tens of thousands and will continue to displace thousands of people for many, many, many decades to come.

Figure 8.7 The Hanford Site, B Reactor in the Distance, Spring 2016, Image by the Author

8.4.2 Chernobyl's Legacy Phase, A Catastrophe

Unlike Hanford, where plutonium production reactors had come to the end of their useful lives and whose eventual closure had been anticipated, two reactors at the Chernobyl Nuclear Power Plant were still under construction at the time of the accident in 1986. With many years left on the 30-year operating licenses for the other four reactors, reactor operators and plant managers gave little thought to decommissioning. Then, in the early morning hours of April 26, the unthinkable happened. Explosions and fires at Unit 4 sent clouds of radioactive gases into the sky. The reactor core melted and oozed into the basement of the building. (See Chapter 6 for more details.) Waves of physical, emotional, and psychological displacement of local residents and clean-up crews ("liquidators") followed.

8.4.2.1 The Liquidators

Believing that the reactor core remained intact, the deputy chief engineer in charge that fateful morning put out a call to the local fire brigades to send men to help douse the fires that burned in and around Chernobyl Unit 4. One reactor operator had died on the scene; another died shortly after arrival at the local hospital. The firefighters who arrived found not just one but many fires burning. The roof of Unit 3, made of a flammable material that had previously been banned from use in industrial buildings, was burning in five different locations.[169] The roof of the turbine hall that served both Units 3 and 4 was in flames. Chunks of smoldering graphite littered the area around Units 3 and 4. And Unit 4 was burning. Twenty-eight of the first firefighters on the scene succumbed to acute radiation sickness. As doctors told one man's wife, "That's not your husband anymore, not a beloved person, but a radioactive object with a strong density of poisoning."[170] The firefighters were buried in zinc or lead lined coffins covered in concrete in a Moscow cemetery.

> If anyone got indignant and wanted to take the coffin back home, they were told that the dead were now heroes, you see, and that they no longer belonged to their families. They were heroes of the State. They belonged to the State.
>
> Lyudmilla Ignatenko, Wife of Deceased Firefighter[171]

The official death toll of the Chernobyl accident stood at 30.

Soon thereafter, thousands of able-bodied men from all over the Soviet Union found themselves on trains and buses destined for Chernobyl. Some had just served in Afghanistan and were looking forward to a return to civilian life.[172] Some had families they left behind. Some felt it their duty to serve when called, even if they had no idea of their destination. The government appealed to their sense of masculinity, to their pride in serving the motherland. They would be heroes. And if they refused to go, they could be shot.[173]

As mentioned in Chapter 6, the liquidators flew the helicopters over the stricken reactor to fill it with sand, boron, lead, clay, and dolomite. The liquidators dug tunnels under the reactor in an attempt to cool down the molten reactor core. The liquidators buried the radioactive forests, destroyed radioactive gardens, poured special solutions on the roads to keep the dust from rising and spreading radiation further, shot animals that roamed freely about the abandoned exclusion zone and buried their remains. They drank vodka. An estimated 600,000 liquidators took part in a variety of activities to cap the reactor and prevent the spread of radiation.

Officials were expected to keep track of the exposure of each of the liquidators, but many liquidators questioned the accuracy of the numbers written down.[174] One remembered his dose recorded as 21 R despite having flown in a helicopter over the reactor for two hours at night, circling to get infrared photographs.[175] He knew that the amount of radiation at the helicopter base in the town of Chernobyl varied between 80 and 120 R. Yaroslav Oleynik, of the 633rd Fire Battalion of Ivano Frankivsk in western Ukraine recalled,

> They gave us these devices, and put them onto our clothing. They would check them every day, but after the third day they just took them away from us . . . They realized that everyone was overexposed every day. Then they started telling us to write down how much radiation we

> were exposed to after each shift, so we wrote down any number, because we had no idea.[176]

Other liquidators were never told their actual exposure. They just knew that their bodies could not take any more radiation when they were informed it was time for them to leave Chernobyl.[177] The liquidators received a medal, a monetary stipend for their service, and a promise of social benefits. And afterward, according to Oleynik, "At first the attention from authorities was there. They treated us well, because they knew who we were. But later the authorities forgot about us."[178]

According to a report issued by the Chernobyl Forum in 2005, only people on site at the time of the accident and the emergency workers who arrived during the first days afterward—about 1,000 people in all—received doses of radiation that would prove fatal during their lifetimes.[179] The majority of the liquidators received "relatively low whole-body radiation doses, comparable to background radiation levels.[180] The report goes on to reiterate the results of other studies: It is impossible to determine the numbers of fatal cancers caused by radiation exposure at Chernobyl.[181] Non-fatal radiation-induced cancers cannot be distinguished from those due to other causes, such as poor nutrition, smoking, excessive drinking, or a lack of adequate health care. However, as indicated by the liquidators themselves, the official records of doses received seriously underestimate the true amount of radiation to which the workers were exposed. For many liquidators, officials on site kept no records at all. Others suggest that their records have disappeared.[182] Any calculations of the risks of cancer among liquidators based on official documents would not reflect the true risks faced by those who spent months shoveling and digging, sleeping in tents or on the ground in the exclusion zone,[183] eating food that may or may not have been contaminated, and wearing the same clothes day in and day out.

> We knew where he was going . . . he didn't even wear a hat. The rest of the guys he went with lost their hair a year later, but his grew out really thick instead, like a mane. None of those boys is alive anymore. His whole brigade, seven men, they're all dead. They were young. One after the other. The first one died after three years. We thought: well, a coincidence. Fate. But then the second died and the third and the fourth . . . My husband died last.
>
> His mom used to come: 'Why'd you let him go to Chernobyl? How could you?' It didn't even occur to me then that I could keep him from going, and as for him, he probably didn't think it was possible to refuse. That was a different time, a military time.
>
> He died alone . . . He died and lay there, he was so hot. You couldn't touch him. I stopped the clocks in the house when he died. It was seven in the morning.
>
> Valentine Panasevich, Wife of a Liquidator[184]

Liquidators who died, died alone, most often in the special wards in a Moscow hospital, isolated from their friends and families. Those who survived often suffer from headaches, heart ailments, high blood pressure, neurological diseases, cancer, depression, and other psychological problems.[185]

The liquidators took time out from their lives to help save the people of the USSR from the unfolding catastrophe at Chernobyl, to clean-up the aftermath of the explosions and fires, and to build a concrete structure to contain the remnants of Unit 4. They returned home changed men. All will be linked forever to the world's worst nuclear accident. Many lost girlfriends or wives who feared they too might be contaminated by Chernobyl's radiation.[186] Many fell ill and could not hold onto their former jobs.[187] They were declared invalids. Others reported their children were born with congenital heart defects, weak immune systems, or developmental delays.[188] The liquidators served the motherland but she failed to follow through on promises to take care of them after that service.[189] The countries that replaced the USSR failed to provide for them. They lost their friends, their social support systems. They felt abandoned with no one to turn to. They became outcasts. Physically displaced in the beginning, they remain emotionally and psychologically displaced as time passes.

8.4.2.2 Evacuees

Officials on the ground at Chernobyl and even a group flown down on April 26 from Moscow refused to believe the extent of the damage to the reactor and the evolving crisis at Unit 4. It was not until April 27 that a nuclear physicist with the government commission confirmed that the core continued to emit enormous amounts radioactive material into the atmosphere, endangering the local population.[190] Official protocol of the International Commission on Radiological Protection required evacuation when the expected dose received by an individual reached 75 Rem integrated over time.[191] On April 26, the measured level of radiation in Pripyat was only 10 mRem per hour—not enough to warrant an evacuation. But that level continued to climb. By the time busses from Kiev had arrived in the town, readings reached 1,000 mRem per hour.[192] People needed to leave. "Comrades. In connection with the accident at Chernobyl nuclear power station, the evacuation of the town is announced. Take your documents, essential clothing and food for three days . . ."[193]

At the time of the first evacuation officials knew little about the direction the radioactive clouds had taken, where or how much radioactive material had been deposited on the land, or where to take the busloads of people from Pripyat and neighboring villages. Evacuees found themselves in villages of the districts only 40 to

50 km to the south and west of the Chernobyl plant. Because there had been no evacuation plan, children got separated from parents, parents from grandparents. Many of the locations to which they were evacuated also received high doses of radiation and soon everyone moved again.[194] Some people took it upon themselves to find new accommodations, and set out on foot.[195] The reception was not always welcoming.[196] No one wanted radioactive people in their neighborhoods or playing with their children.[197]

> From the very first I felt that we were Chernobylites, that we were already a separate people. Our bus stopped overnight in a village; people slept on the floor in a school, others in a club. There was nowhere to go. One woman invited us to sleep at her house. "Come," she said, "I'll put down some linen for you. I feel bad for your boy." Her friend started dragging her away from us. "Are you crazy? They're contaminated!" When we settled in Mogilev and our son started school, he came back the very first day in tears. They put him next to a girl who said she didn't want to sit with him, he was radioactive. Our son was in the fourth grade, and he was the only one from Chernobyl in the class. The other kids were afraid of him, they called him "Shiny." His childhood had ended so early.
>
> Nadezhda Vygovskaya, from Pripyat[198]

A second stage evacuation occurred a few days later, moving people living within a 30 km radius of the plant away from the area, relocating the rural population and their livestock, and transporting women and children further from the stricken plant, often to camps along the Black Sea.[199] Dr. Maksim Drach, called from Kiev to help with medical examinations, noted that most of the people in the second evacuation were old, bent grannies, gray-haired grandpas, and very young children. He was informed that the others had stayed behind to help out with the clean-up work in the exclusion zone.[200]

Those taken out of Chernobyl's exclusion zone were not always happy in their new surroundings. Some found themselves squeezed into already overcrowded houses, sleeping on "the floor, sometimes two to a single mattress, eight or nine people crammed into one house."[201] Most had little money. Some had forgotten important documents behind in the rush to leave and could not find work or renew their pensions. Others had to say goodbye to a lifetime of experiences and memories.

> We were leaving—I took some earth from my mother's grave, put it in a little sack. Got down on my knees: 'Forgive us for leaving you.' I went there at night and I wasn't scared. People were writing their names on the houses. On the wood. On the fences . . .
>
> Woman evacuated from Bely Bereg, Gomel Oblast, Belarus[202]

> . . . I lived at my son's on the seventh floor. I'd come up to the window, look down, and cross myself. I thought I heard a horse. A rooster. I felt terrible. Sometimes I'd dream about my yard: I'd tie the cow up and milk it and milk it. I wake up. I don't want to get up. I'm still there.
>
> Woman evacuated from Bely Bereg[203]

By law, everyone in the zone had to be evicted. Officials organized the construction of new houses for evacuees, regular doctor visits, and shipments of "clean" meat, cheese, and milk.[204] Even so, a number of the older residents absolutely refused to leave.[205] Others returned to the area they knew as home (like Maria's cottage pictured in Figure 8.8 below). Between 1,000 and 1,200 semi-legally populated that land.[206] According to three of those residents:

No one's going to fool us anymore, we're not moving anywhere. There's no store, no hospital. No electricity. We sit next to a kerosene lamp and under moonlight. And we like it! Because we're home.[207]

Even if it's poisoned with radiation, it's still my home. There's no place else they need us. Even a bird loves its nest . . .[208]

I have two bags of salt. Who needs the government? Plenty of logs—there's a whole forest around us. The house is warm. The lamp is burning. It's nice! I have a goat, a kid, three pigs, fourteen chickens. Land—as much as I want; grass—as much as I want. There's water in the well. And freedom![209]

Figure 8.8 Al Fresco at Maria's in the Exclusion Zone, Summer 2007, Image by the Author

When data became available that areas outside the exclusion zone also received high levels of radiation, due to the wind direction and rainfall, attempts were made to wash down and decontaminate villages without resettling their inhabitants.[210] Liquidators destroyed and replaced wooden homes and barns and removed topsoil from gardens. They covered roads in a new layer of asphalt.

In Kiev, the capital of Ukraine, and other cities around the region, traditional May Day celebrations took place in 1986, with parades of ethnic costumes, bands, floats, and shows of dedication to the Communist Party. That same day the levels of radioactivity peaked over Kiev.[211] Since that day, many have questioned the decisions to allow the festivities to continue. Did local officials not know of the potential dangers of radiation, particularly to the children gathered on the streets? Did Soviet officials want to prevent widespread panic within the general public?

Unbeknownst to many, nuclear authorities had raised the yearly maximum allowable dose of radiation from 0.5 Rem to 10 Rem.[212] Soviet officials had notified people involved with the Chernobyl accident that all information was considered a state secret, even the last names of those who had perished.[213] Liquidators signed non-disclosure forms and were told by KGB representatives not to talk to anyone about what they had seen.[214] On May 9 Radio Moscow announced that all was normal in Kiev and *Pravda* reported that residents of Kiev had nothing to fear.[215] The General Secretary of the Central Committee of the Communist Party of the Soviet Union, Mikhail Gorbachev, finally addressed the nation on May 14, 1986.

Despite the push for secrecy, health officials in Ukraine had begun taking actions of their own. Beginning May 1, milk sales in Kiev had been banned.[216] By the eighth of May residents had been warned not to eat spinach, sorrel, or salad greens.[217] Drinking wells needed to be covered and apartments needed to be wiped down with damp rags to prevent the spread of radioactive dust. Parents were told to keep children from playing on the ground. Families did not, however, receive information about why these actions were necessary.

Families also failed to receive iodine supplements to stave off the effects of radioactive iodine 131. Iodine 131 enters the blood and settles in the thyroid gland and within days begins destroying cells. Filling the thyroid with other forms of iodine would prevent iodine 131 from lodging in the body.

> In the civil defense instructions we had then, you were supposed to carry out an iodine prophylaxis for the entire population if there was the threat of a nuclear accident or nuclear attack. That was in the event of a *threat*.
>
> Vasily Nesterenko, former director of the Institute for Nuclear Energy at the Belarussian Academy of Sciences[218]

For people in rural areas, one of the largest sources of iodine 131 was the consumption of milk from local cows. As at Hanford during the Green Run and other emissions events, the iodine 131 deposited on the grasses, the cows consumed the grass and passed radioactive iodine on in a concentrated form through their milk. For children with growing bodies in particular, consuming radioactive milk proved disastrous. By 2002, over 4,000 thyroid cancer cases had been diagnosed among those who were children at the time of the catastrophe at the Chernobyl plant and drank milk shortly thereafter.[219]

Much like the compartmentalization of information prized by General Groves at Hanford, the Soviets favored a policy of secrecy based on a division of information into pieces.[220] Only those at the top of the command structure, with access to all the different pieces would be able to understand. Officials continued to reassure the public that Soviet nuclear power stations were the safest in the world.[221] "The truth about Chernobyl is known to those who are supposed to know. And those who are not supposed to know can just go on living the way they were before" (Vladimir Ivanov, Soyuzatomenergo—the Ministry of Energy and Electrification).[222] Censorship had been designed to keep the public from learning things the Soviet State wanted to keep secret.[223] The general public was to be kept in the dark about the events at Chernobyl. However, people began to hear about Chernobyl from radio broadcasts from the West.[224] Those used to receiving all their news from the State doubted what they heard ("We were used to believing . . ."[225]). Those who had begun to mistrust the State feared it was true.

Officials evacuated between 115,000 and 120,000 people from the highly contaminated exclusion zone in 1986.[226] In subsequent years the Soviet government also designated an additional zone of ''special strict control" and a zone of "periodic control".[227] Dosimetric measurements in those zones determined which areas required evacuation, which received decontamination, which farmers' livestock and equipment was destroyed and replaced and what was salvaged. Some farm families received payments to compensate them for the need to purchase foodstuffs they once produced themselves. Still, the exodus continued. By 2000, approximately 350,000 people had been forced out of the various zones around Chernobyl. Over 47% had left homes in Ukraine, 39% came from villages and farms in Belarus, and the balance from the Russian SSR.[228]

Figure 8.9 Spaces of the Exclusion Zone, Summer 2007, Images by the Author; Clockwise from the upper left: Dennis, a tour guide, checking radiation levels; Soviet-style light fixture in Pripyat; A sign to nowhere; Car from a never-used Ferris wheel in Pripyat; Monument to the firemen who lost their lives at the reactor; Abandoned cottage

8.4.2.3 Chernobyl and Displacement

Despite the passage of time, the catastrophe at Chernobyl Unit 4 continues to impact hundreds of thousands of lives. Although epidemiological studies do not confirm the link, the liquidators and their families continue to report a host of illnesses they believe stemmed from their days worked at the site. Their experiences at Chernobyl changed their lives forever. As a result, many have spent years battling the bureaucracy of health systems and benefits systems, only to be turned away. Like

Hanford's Downwinders, they feel bitter, angry, shut out, and abandoned. Physically displaced to heed to call to duty, they remain emotionally displaced by the very groups they thought would be there to help them.

Those evacuated from the towns, villages, and rural areas around the reactor have suffered a similar fate. They left behind their homes and land and all their worldly possessions. They severed family ties, ties to past generations, and ties to all that was familiar to them. Ancestors lay alone in cemeteries within the exclusion zone—families visit once each year on "Parent's Day."[229] People from farms found themselves in apartment buildings in cities with no comprehension of how to lead their lives. People from small towns where they knew just about everyone found themselves in Kiev or Minsk where they knew no one. They lost the physical and social structures that had helped them understand who they were and how they fit into the grand scheme of life. They were outsiders wherever they went—worse yet, they were "Chernobylites." They had been displaced.

A barbed wire fence still marks the border of the exclusion zone around Chernobyl. In 2017 the new containment structure will roll into place to seal off the remains of Unit 4 for the next 100 years. The aging, rusting radioactive hulks of helicopters that flew over the reactor, trucks that sprayed down the dusty lanes, buses that evacuated people, and military vehicles that prowled the zone will continue to sit in overgrown fields, awaiting a final resting place. Boats and barges on the Pripyat River housed some liquidators, but have become embedded in the mud. Unlike Hanford, where work is under way to demolish the structures of no historic significance, the buildings of Pripyat and villages not destroyed by liquidators in 1986 have been left to the ravages of time, looters, and the weather. As at Hanford, curious outsiders can venture into the zone on guided tours (with an obligatory radiation check at the conclusion). Scientists can work in the zone. For the rest of the world, it continues to remain off-limits.

8.5 What have we learned?

Examples taken from the cases of Jaitapur, Hanford, and Chernobyl have validated the Process Model of Displacement. Displacement is not limited to the act of leaving a home, a dwelling place and moving personal belongings to another location. Displacement involves the ebb and flow of people over the life cycle of a nuclear technology project. It encompasses emotional and psychological dimensions as well as physical ones. Displacement is a multi-dimensional, multi-faceted process.

As soon as community members hear about a potential project, aspects of emotional and psychological displacement emerge. People begin to worry about the impact of the project on their ways of life. Near the proposed Jaitapur Nuclear Power Plant, fishermen feared the loss of access to fishing grounds and what a future might hold for them if they cannot make a living catching and selling fish. Women who collected mollusks worried that their supply would be wiped out as environmental conditions change due to hot water discharges from the plant. Having heard of the aftermath of the accident at the Chernobyl Nuclear Power Plant and issues related to other nuclear facilities in India, villagers expressed concern about the impacts of radiation releases on their health and that of their children.

Land acquisition adds physical, cultural, and social displacement. In the Jaitapur region, villagers lost access to grazing land and parcels on which they grew rice and food to feed their families. Compensation disputes drove wedges between family members. At Hanford, Native Americans lost access to fishing and hunting grounds, and tribal meeting places. Centuries old cultural practices came to an end. Farmers had to abandon carefully tended fruit orchards and the U.S. Army forced them to relocate, sometimes to other farming communities, sometimes to cities in Oregon and Washington. Social networks were torn apart.

> ". . . that was very hard on them, and no future, no money, cash in hand, like that they could go out and buy another place. And most of them had just been farmers, so they were spread all over. I mean, they moved wherever they could get a place to live."[230]

The start of construction brings new waves of people to an area. Construction workers at Hanford and the "shock workers" at Chernobyl only expected to stay as long as their jobs lasted and never set down roots. They lived in temporary quarters, with little to occupy them but the entertainment provided by their employers, drinking and carousing.

Operations personnel physically replace construction workers as nuclear reactors begin to feed electricity to the electric grid. The villagers near Jaitapur worried about the clash of cultures as these new groups would move into their area: differences in language, dress, festivals, food preparations, and manners. People employed at the Jaitapur nuclear power plant will live in a gated enclave, not among the locals, but may shop and do business in the local villages. How will the groups get along? At Hanford, because existing towns had been destroyed, operations personnel were forced to establish new social structures and networks of relationships in Richland, Kennewick, and Pasco. They put down roots to weather the "termination winds" and the winds of change as the contractors overseeing the site and its primary mission changed.

Many of the operations personnel at Hanford continue to reside in the area, even as the site has shifted into a Legacy phase. New sets of contractors have been brought in to deal with the clean up and remediation of decades of toxic waste. At Chernobyl, liquidators swarmed the site after the catastrophe of 1986 to tame the fire and explosion and help clean up the designated exclusion zone. Chernobyl also entered a Legacy phase. Although people living near the Chernobyl Nuclear Power Plant were evacuated to new villages or apartments, they carried with them the stigma of being from “there”. Evidence now shows that at both sites, clean up workers and local residents were and continue to be exposed to levels of radiation exceeding the standards set by their respective governments. And yet, people at both Hanford and Chernobyl have had to fight legal battles to gain compensation to pay for medical bills they believe are related to working and living near those nuclear power facilities. Emotional and psychological displacement accompany the physical displacement that resulted from events leading to the posting of the rusted signs around the sites that read “Stop!” and “No Trespassing”.

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Chapter 9

A POLICY AND RESEARCH AGENDA FOR DISPLACEMENT

> I do have a sense of displacement as constant instability—the uninterrupted existence of everything that I love and care about is not guaranteed at all. I wait for catastrophes.
>
> Aleksander Hemon, Bosnian-born American writer

In the preceding chapters I have demonstrated the value of the Socio-Political Ecology framework and the Process Model of Displacement. The Socio-Political Ecology framework draws attention back to the social implications of the use of nuclear technology. Alongside cost-benefit calculations, lifecycle cost analyses, and probabilistic risk assessments, government agencies and other organizations contemplating nuclear projects need to take a serious look at the impact those projects will have on the local communities and the people they expect to employ. Plans to build and operate nuclear facilities have wide-reaching impacts on those who live near the site, on those who relocate to help with the construction and operation of those facilities, and ultimately on the people who must cope with the enduring legacy of the nuclear plant operations. This dissertation has focused on the physical, emotional, social, and psychological displacement of people throughout the lifecycle of a nuclear project. Whereas most analyses of displacement characterize it as a one-time event, associated with the construction at the site or a catastrophic accident, I have shown that displacement begins as soon as communities hear about the plans for a nuclear project and continues long after the doors have closed on reactor buildings. Furthermore, the displacement associated with a nuclear project can extend well beyond its boundaries. Emissions from Hanford's "Green Run" affected people in Spokane, WA—over 150 miles away; Chernobyl's liquidators returned to homes spread across the former Soviet Union.

In this chapter I move beyond that examination of displacement to look at interesting commonalities and some differences among the three case studies. What can be learned by taking that broader look at displacement? I then look at existing policy structures for including the public in decision-making about nuclear facilities and other mega-projects to understand the opportunities for improvement. In light of the many concerns expressed over the construction of the Jaitapur Nuclear Power Plant and the enduring legacy of the Chernobyl catastophe, I present several options for providing electrical generation. Finally I propose several avenues for future research that build on this foundation.

9.1 Implications of Displacement

Despite being separated by decades in time, oceans and even continents, despite the differences in governments and the purpose behind the operations, the archival research and interviews related to Hanford, Chernobyl, and the proposed Jaitapur Nuclear Power Plant have revealed striking similarities in displacement among the sites and across the phases of the life cycle of the nuclear projects. First, during the Planning Phase, officials in India and the United States tried to use money to recompense the people of the Jaitapur area and the original inhabitants of the Hanford site for their losses. In India, government officials declared the land barren and paid much less than families had invested in that land over generations. Although money could be used to build new houses or buy farmland in a different part of Washington, it could never compensate for the losses of social networks, traditional ways and experiences. Money could not take away the anxiety of an uncertain future, the anger at being brushed aside by officials, or the fear of what a nuclear facility could mean for the local community.

During the Construction Phase, compensation also played a large role. Above average salaries lured workers to Hanford and kept them from leaving, despite the less than welcoming conditions they faced. Large quantities of food not generally available during a time of war and special entertainment served as added enticements for people who made Hanford only a temporary home. Even later, as new projects revived construction at Hanford, people came to work as electricians, woodworkers, pipefitters, and the like, making good money for the duration of a contract. The opposite might have been true for those involved in the construction of the Chernobyl Nuclear Power Plant. The Soviet system that had successfully transformed an agrarian society into an industrial one in the decades after World War II found it difficult to maintain productivity and discipline among workers who lacked skills for the jobs to which they were assigned, received low wages, and lived in areas with few social amenities.[1]

Operations drew an entirely different cadre of people to Hanford. Scientists and engineers came with their families to make eastern Washington their home. They had left behind family and friends and began to establish roots in the area. What had been a quickly erected company town for DuPont and the U.S. Army blossomed into a small community with civic organizations and festivals, schools, a public library, and, eventually, small businesses. Because of its close ties to Hanford, rather than fearing the nuclear technology project just to the north, the town of Richland embraced it. The high school changed its mascot from the Beaver to the atomic bomb in 1945. In the 1980s it adopted the mushroom cloud as its new logo.[2] Even so, the remoteness of the site, the demands of the jobs, followed by uncertainty about the future in the face of ongoing changes at the Hanford site did make it difficult for some to completely commit to a life in eastern Washington.

Displacement during the operations phase also stemmed from the secrecy surrounding the operations at Hanford and the emissions emanating from the site. People felt betrayed and lied to. Their health and the health of their families and neighbors had been compromised by the government and their employers. And yet when they did seek monetary compensation for their health related expenses, they faced protracted legal battles. Lawyers for the Hanford contractors belittled their claims of illness. The experiences left people feeling frustrated, angry, and helpless.

At Jaitapur, the close link between military and civilian applications of nuclear power and the dual role of the Department of Atomic Energy as supporter of nuclear power and protector of national security made it impossible for people to get access to information beyond what the Nuclear Power Corporation of India supplied to them about the proposed plant. Even filing requests under the Right to Information Act (2005) came to naught.[3]

Secrecy also overshadowed the events that followed the catastrophic accident at Chernobyl. Liquidators labored to quench the fires at the plant without proper gear to shield them from life-threatening doses of radiation. The people of Pripyat carried on their normal daily activities, unaware that they breathed and played in radioactive cesium, iodine, strontium, and other toxic substances. Only during investigations into the disaster did anyone question why the United States had not approved a RBMK-like design for use within its borders—because it lacked safety features and could become unstable during operations.[4] In fact, 104 emergency stoppages had been logged at the Chernobyl RBMK units between 1981 and 1985.[5] Secrecy and a lack of open communication at Hanford, Chernobyl, and Jaitapur meant that only those in charge of the projects had key pieces of information. Using the terminology introduced by Relph, because of their control of information, those in charge became the "insiders," whereas the local communities, workers, and evacuees became "outsiders"—alienated from the places to which they were once so closely attached.

At both Hanford and Chernobyl, the Legacy Phase involves a modern world coping with the remnants of decisions made and radioactive waste generated decades before. At Chernobyl, a catastrophic accident resulted in the physical resettlement of those residing in the nearby villages and the work of hundreds of thousands of liquidators to cap the stricken reactor and mitigate the damages to the areas within the exclusion zone. Evacuees from the exclusion zone received approximately $1,000 in compensation plus the promise of housing.[6] Liquidators received a medal and a bonus check. The physical and mental health impacts of those events have followed both groups of people across the former Soviet Union. Many have since died, others cannot work and they long for the life they once lived. The ongoing clean up at Hanford also takes its toll. While contractors argue the conditions at the site are safe, workers at the Tank Farms (the location of the tanks holding liquid and sludge waste in 177 single- and double-walled tanks) continue to report of breathing and other problems. Efforts to clean up the site have fallen far behind schedule. In the meantime, the cost of clean up efforts at both Chernobyl and Hanford continue to rise: It will cost $2.5 billion for a new safe containment structure for Unit 4 at Chernobyl; the cost to finish the clean up at Hanford has been estimated at about $108 billion.[7]

In addition to Hanford, the United States has yet to grapple with the more than 76,000 metric tons of spent nuclear fuel from decades of operation of its commercial nuclear reactor fleet.[8] Globally, spent fuel amounts to almost 270,000 metric tons.[9] Ten sites—in China, France, India, the Russian Federation and the United Kingdom—can reprocess spent fuel. Elsewhere, plans are being made to store the waste for hundreds of thousands of years.[10] For example, as of this writing, construction is under way on an underground repository for nuclear waste in Finland.[11] Forty years of research have gone into designing the system of copper canisters and caverns that will eventually seal the waste 400 m (over 1,300 feet) below the surface. Even when the "100,000 year tomb" is completed, someone or something will need to keep future civilizations from disturbing its contents.[12] Physical displacement will endure.

Table 9.1 below provides a summary of this discussion.

Table 9.1 Summary of Displacement Implications

Source of Displacement	**Implications**
Land Acquisition	Conflicts can arise during the land acquisition process as a result of differing perspectives and objectives. Landholders are "placeholders," in the sense that they maintain the history, family ties, social structure, economic structure, experiences, etc. of the community in their piece of land. Those in charge of nuclear projects take an impersonal, business approach to the acquisition and aim to purchase land at the lowest possible price.

Table 9.1 continued

Compensation	Conflicts over compensation arise from a difference in perspectives: Those in charge of nuclear projects take a business and economics approach and have failed to take into account the on-the-ground reality of the properties involved, the investment of time, effort, and capital needed to coax crops out of the ground. Reaching an agreement on what is "equitable" may be difficult. Compensation for builders of and workers at nuclear facilities must account for the risks involved in operating those facilities.
Health Compensation	Issues related to getting compensation for health impacts of nuclear technology projects include: 1. Denial of a connection between health problems and a nuclear facility, 2. Coverage rarely supports a lifetime of impacts of exposure to radiation, 3. Exposure to radiation may extend beyond the boundaries of the project site but coverage may not, and 4. The legacy of secrecy at sites prevents those who may have been exposed to radiation from knowing.
Secrecy / Communication Policy	Lack of open communication from those in charge of a project leads to anger, distrust, feelings of not being heard or being belittled as seen at in the Planning Phase at Jaitapur and the Legacy Phases at Hanford and Chernobyl. This leads to a lack of support from the local people and employees, and can result in project delays and costly lawsuits. However, the truth eventually does come out.
Worker Relocation	Nuclear technology sites tend to be large and located in remote areas. The need to bring in various types of outside workers to construct and operate the facilities can cause social and cultural upheaval for those living inside the village/town created for the project as well as the local communities.

Table 9.1 continued

Fences and Walls	Fences and walls serve as visible signs of separateness at every stage of a nuclear technology project. Most basically, they provide a physical barrier keeping sites off limits to the general public. They also symbolize the existence of insiders and outsiders, of powerful groups of people who possess information and others kept in the dark. Those working within the walls and fences put their faith in science and technology for economic development and to solve problems of modern life.
Nuclear Legacy	Even after its closure, a nuclear facility continues to affect both the human and natural environments. People exposed to radiation due to a catastrophe or those involved in clean up operations suffer from a host of diagnosed and undiagnosed illnesses. Issues of waste disposal and site contamination prevent the land acquired for a nuclear technology project from returning to its original function—it remains off limits. Waste will need to be isolated for centuries to come. We trust that the waste will be safeguarded well into the future, not allowed to leak into the environment and not used to create atomic weapons.

9.2 Towards a New Policy Framework

Much of the emotional, psychological and social displacement associated with Hanford, Chernobyl, and Jaitapur stemmed from poor or foregone communications between agencies, companies, contractors, and employees at the sites or local residents. In the early days of Hanford, the urgency of war made secrecy imperative. The monolithic Soviet state carefully controlled information to maintain its image as a military, industrial, and technological powerhouse.[13] However, since the 1970s, agencies and organizations preparing to undertake large projects, like the construction of nuclear facilities, have been required to evaluate the environmental, economic, and social impacts of those projects.

President Richard Nixon signed the groundbreaking National Environmental Policy Act (NEPA) on January 1, 1970. NEPA requires that federal agencies and organizations requiring federal permits explicitly consider the impact of their proposed projects on the *human* and natural environments. According to the Act, they must

> (1) Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
>
> (2) Assure for all Americans safe, healthful, productive, and aesthetically pleasing surroundings;
>
> (3) Attain the widest range of beneficial uses of the environment without degradation, risk to health and safety, or other undesirable and unintended consequences;
>
> (4) Preserve important historic, cultural, and natural aspects of our natural heritage . . .
>
> (5) Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities . . .[14]

NEPA also recommends an interdisciplinary approach to identifying the impacts of proposed projects and their significance, consideration of reasonable alternative actions for achieving the same end result, and the pursuit of public input.[15] The approach should draw on a range of natural, social, and environmental sciences in developing plans and recommending courses of actions regarding projects. Agencies and organizations also must take into account the "worldwide and long-range" character of environmental issues rather than a short-term and project-specific view of their obligations.[16] California, Washington, Minnesota, Georgia, and New York followed shortly thereafter with state level environmental impact assessment (EIA) requirements.[17] (That list has since grown to include 16 states, Puerto Rico, and the District of Columbia.[18])

In 1973 and 1974, Canada, Australia, and New Zealand adopted similar programs.[19] The approach continued to spread globally through the 1980s and 1990s as concern for the environment and the size and scope of projects increased. Each nation adopted requirements specific to its own circumstances and procedures congruent with existing national laws, processes, and administrative structures. As a result, while the goals of EIAs (also referred to as Environmental Assessments or EAs) remain the protection of the environment, the specifics vary by country. In addition, rather than being used as tools for use at the project level, many developing nations integrated EIAs into land use planning protocols.[20]

In 1989, the World Bank adopted a form of environmental assessment to evaluate the potential environmental disruption from projects it was being asked to finance.[21] In doing so, the World Bank acknowledged that the traditional focus on economic objectives had led to widespread destruction in places like the tropical rainforests of the Brazilian Amazon. Similarly, in its approval of loans for the Sardar Sarovar projects along the Narmada River in India, the World Bank had focused on the project costs and the benefits of hydropower (electricity access), irrigation, and water allocation. The initial resettlement and economic rehabilitation plan for the project had met with the Bank's approval. However, concerns raised by opposition groups about the displacement of small farmers and tribals, the piecemeal rather than holistic approach to environmental planning, and the disregard for the conditions imposed on the project by India's Ministry of Environment and Forests led the World Bank to withdraw its support.[22] By codifying the environmental and socio-economic standards for its economic assistance, the World Bank sent a signal to all potential recipient countries that it stood behind the principles of sustainable development that had been articulated by the World Commission on Environment and Development and the Brundtland Commission. That is, sustainable development should be undertaken without compromising the ability of future generations to meet their needs. As such, people, businesses, and governments needed to address the irreversible degradation of the natural environment and the burden placed on the poor and marginal populations of the world to fuel the economic growth in the developed world.

Water and air pollution prevention and control acts had been introduced in India in the late 1970s and early 1980s in an attempt to control sewage, agricultural runoff, automobile and industrial pollution. Following the Bhopal tragedy of 1984, during which toxic methyl isocyanate leaked from a Union Carbide plant, killing approximately 15,000 people, the Indian government sought to strengthen its emissions laws.[23] The 1986 Environmental (Protection) Act expanded the regulation of the discharge of hazardous pollutants, giving the government and its agents the authority to set limits on the amounts of toxic substances being released into the air, water, and soil. Individuals or companies found in violation of the Act could be fined or imprisoned. However, the Act did not address the impacts of continuing development on the landscape. By 1994, the Ministry of Environment and Forests had amended the Environmental (Protection) Act, making an environmental clearance mandatory for the expansion or modernization of a wide variety of industries, or for establishing new projects in those same industries. Industries covered by the new ruling ranged from thermal power plants, the sugar industry, cotton and woolen mills, rubber processing, leather tanneries, cement plants, the fertilizer industry, metal processing, petrochemicals and oil refineries, to food and drink processing[24]—the very types of large-scale industries, the construction and operation of which can cause emotional, psychological, social, and physical displacement.

While progress has been made, the noble promise of safeguarding the natural and social environments from the negative impacts of energy, industrial, and development projects, either through NEPA, EIAs, EAs, or India's Environmental (Protection) Act, has not quite materialized in practice. A 1996 analysis of environmental assessments worldwide found that such initiatives have contributed to the identification of the potential consequences of proposals and mitigation measures to address those.[25] Concerns included the need to look at the cumulative effects of projects, the cost effectiveness of the process given its complexity and the amount of data gathering required, and the lack of consensus regarding criteria and methodologies.[26] In addition, and most pertinent for this dissertation, "[s]ocial impact assessment practitioners continue[d] to express concern about the status of their specialization as a "second-class citizen" of the EIA process, and question the extent to which socio-cultural impacts are fully and systematically addressed."[27] Impacts of projects on the health of local communities also needed to be addressed more completely.

A similar study examined the U.S. National Environmental Policy Act after its first 25 years, in 1997. The Council on Environmental Quality concluded that the most enduring legacy of that Act was as a framework for collaboration between federal agencies, those involved in projects, and those who are most affected by them.[28] Among the areas in need of improvement: The EIA process often begins too late in the cycle of development of a project to have any impact on its design or implementation. While the EIA had been conceived of as a way to bring environmental impacts and public concerns about them into the open at the start of the decision-making process,[29] that did not occur in practice. As shown in Figure 9.1, public comment periods usually follow a sequence of events that includes determining the need for the project, developing a project proposal, outlining expected environmental consequences, selecting a number of potential alternatives to the proposed project, and if significant environmental effects will occur, collecting the data for an EIA. At that point, the agencies and organizations involved have invested a good deal of time and money in land purchases and architectural and site designs. As a result, public comment periods usually take the form of presentations by the agencies and organizations—outside input tends to be ignored.[30] The presentations, and the EIAs themselves, tend to be loaded with complex, technical information, not easily accessible to the public.[31] The atmosphere can become adversarial, with the public turning to the court system as a way to have their voices heard.

In addition,

> A major difficulty with the traditional environmental impact analysis process is that it is *a one-time event* (emphasis added), i.e. results from intensive research, modeling, and other computations or expert opinions are analyzed, the analysis of potential environmental impacts is prepared, mitigation measures are identified, and a document is released for public review. Unfortunately, most often the process ends there.[32]

Even if new information about the site or the impacts of the project becomes available, or if conditions at the site change, the EIA is not revisited. Nor does the EIA necessarily require monitoring of the impacts of the project to compare them to what the agencies and organizations had outlined and take remedial action if required.

Once the decision has been filed, sometimes in the Federal Register, sometimes on an agency's website, the process comes to an end.

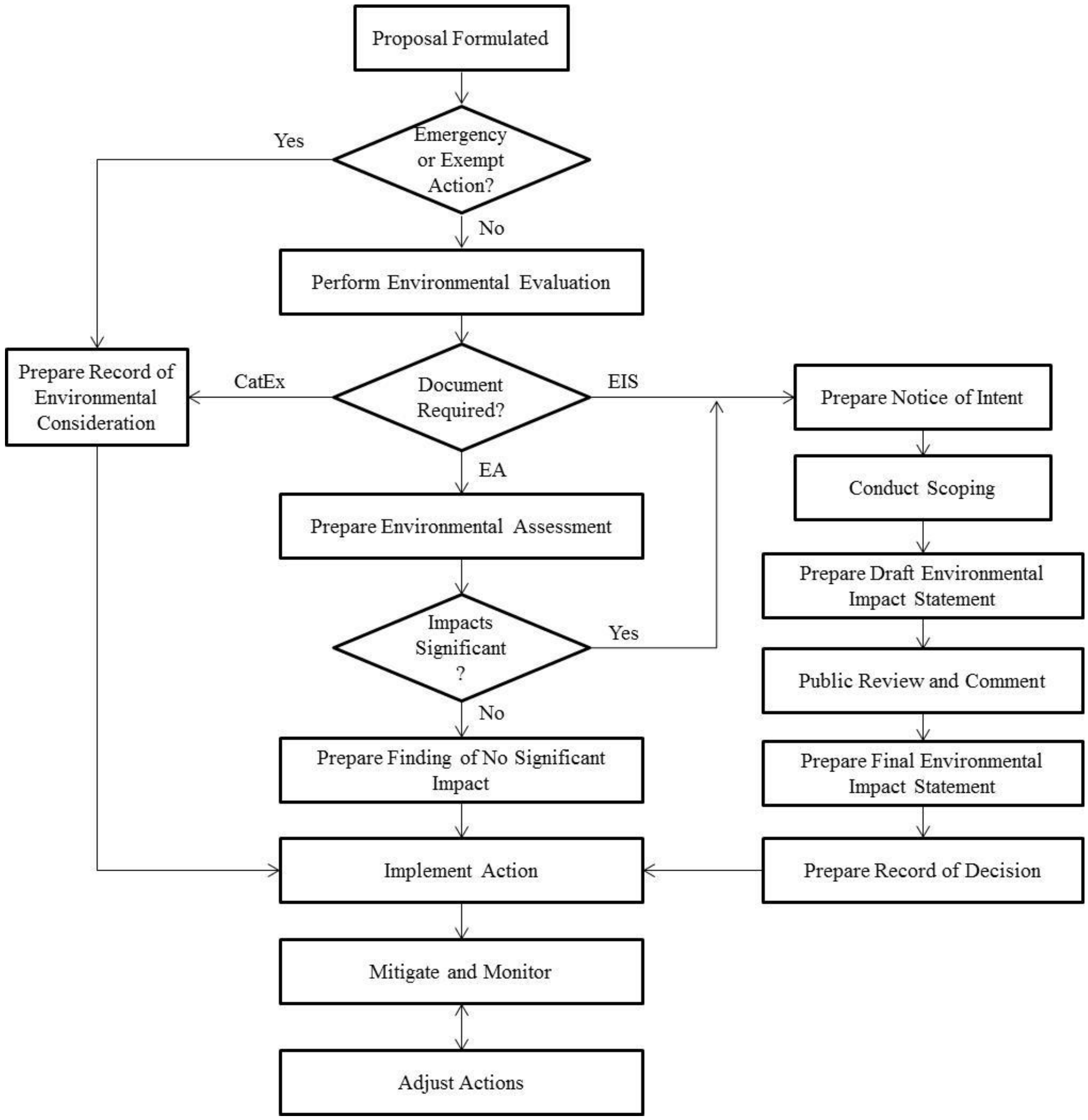

Figure 9.1 The NEPA Process[33]

By the time the plans for the Jaitapur Nuclear Power Plant had been put into place, little had changed. Recommendations to reach out to affected communities earlier on in the EIA process, to work *with* them to gather ideas, had not been incorporated into the Indian approach. As explained in Chapters 7 and 8, land was acquired before the Nuclear Power Corporation of India, Ltd. (NPCIL) held informational meetings in the local communities. Plans for the site had been prepared and foreign companies had been brought on board. Communication remained unidirectional. Villagers felt they did not get answers to their questions in the meetings and, often, those who opposed the project were barred from entry. Eventually, the meetings were moved 60 km (37.3 mi.) away, to Ratnagiri, far from the affected villages, limiting people's ability to provide any input at all.

As mentioned earlier, the conflict arose over how to best assess the social impacts of the project. NPCIL deemed the analysis by the Tata Institute of Social Science--which involved interviews of the local communities--to be unscientific. Indeed, when referring to the impact of the construction of the housing complex, the final EIA only mentioned that it "would generate direct and indirect employment opportunities as daily wage labors" and "may improve the quality of life in the region."[34] The socio-economic analysis of the facility (then proposed to be two reactor units, not six) submitted by the National Environmental Research Institute (NEERI) relied on a quality-of-life index analysis to understand the baseline status of the area surrounding the construction site.[35] The analysis drew of secondary sources of information (census data for example) plus a survey conducted in 61 villages near the site. Key findings reported in the EIA for the Jaitapur project included:

100% awareness regarding the proposed project

> Most of the respondents are engaged in fishing and agricultural activities. Farming is the main occupation . . .
>
> The respondents whose land will be acquired for project are having apprehension on land acquisition.
>
> Wood, kerosene and LPG are the main source of fuels used for cooking purpose[36]

As a result of the findings of this socio-economic analysis, the NPCIL promised financial assistance to upgrade the educational facilities, mobile health clinics and health care services, and the construction of community halls in the area around the project.[37] Fishermen would receive new life jackets, books and computers would be donated to schools, and local cottage industries would be tapped to provide furnishings for the offices, guest houses, and schools attached to the site. Housekeeping contracts at the residential complex and at the plant would be allotted to villagers. Local roads would be improved and widened, street lights would be added, and bus shelters would be constructed. However, nowhere in the report did the NPCIL indicate if any of these community development projects had been requested by or developed in tandem with the community leaders, the sarpanch or panchas of the local villages, or the villagers themselves. Nor was it clear that the community development projects stemmed for any real needs identified in the socio-economic analysis of the area surrounding the Jaitapur site. Everything described bore an uncanny similarity to the projects undertaken by NPCIL at the Kudankulam Nuclear Power Project site in Tamil Nadu and the Kakrapar Atomic Power Station in Gujarat (photos of which were included in the Jaitapur site EIA).

The socio-economic assessment did acknowledge that “Project Affected Persons (PAPs) in the study area have the knowledge about land acquisition for the developmental activity and residential complex. They are also aware of the loss of land, especially their land holdings on which they depend by practicing agriculture."[38] However, no mention was made of attempting to find land to replace that lost by those families or locating agricultural employment for farmers put out of work. In fact, the plan for proper resettlement and rehabilitation, as required by Indian law, was devised separately from the EIA by NPCIL and the State of Maharashtra and included only payment for the land. Likewise, as explained earlier in this dissertation, many of the families in the area have spent generations on the sea. According to the report, "Fishing activity is carried out in some villages."[39] Yet the socio-impact assessment paid no attention to the impact of the construction of the plant or its discharges on fishing in the region. No provisions (other than life jackets) were made for fishermen and the potential loss of their livelihoods. No assurances were given that the fishermen would be able to use their current harbors and fishing lanes, nor were any loan programs established to upgrade fishing equipment if they needed to travel farther out to sea to seek their prey.

Interestingly, the EIA submitted for the Early Site Permit in August 2008 for the Vogtle Electric Generating Plant (VEGP)—the site of the construction of two new AP1000 nuclear reactors on the Georgia/South Carolina border—was similarly detached in its analysis of the socio-economic impacts of the proposed reactors. During construction, about 3,500 workers would be added to the site, with about 2,500 of those in-migrating to the area.

> [T]he staff determined the influx of workers because of VEGP construction activities would only impose SMALL and temporary, unnoticeable demographic impact to the more populous counties . . . Burke county would likely experience MODERATE and temporary impacts . . .[40]

The report did not take into account the potential for cultural differences between the new construction workers and the local communities (a concern raised during my interviews in the Jaitapur area) and did not consider that the temporariness of the construction jobs might result in problems for the workers, resulting in alcoholism, drug abuse, vagrancy, or increases in crime (seen at Hanford, Chernobyl, and more recently at the camps established near the Bakken oil formation in North Dakota or in Fort McMurry in Aberta).[41] The economic benefits of construction crews were also labeled as SMALL and MODERATE.[42] Unlike Hanford, where the U.S. built an entire city to house construction personnel, the workers at VEGP would need to find accommodation the neighboring counties. For about 500 workers, those accommodations would be motel or hotel rooms, rooms in private homes, or campers in temporary recreational vehicle parks. Yet the staff expects the housing-related impacts to be SMALL.[43]

Operation of the two new reactors at the Vogtle site will employ just over 800 people. The socio-economic impact analysis concluded that this small increase would have only a "SMALL impact on workers and the local public and would not require additional mitigation."[44] In reaching that conclusion, the authors of the document only spoke to one member of the local community—an official in the Department of Planning, Permits, and Inspections in Burke County, Georgia. They did not hold focus groups or interview people about their concerns about the addition of the permanent operations personnel to the area. Instead, the authors relied on rational, mathematical calculations: "[I]n-migrating construction workers bring families, with an average of 1.762 dependents per worker. Approximately half of the dependents are assumed to be children, and 74 percent of the children are school age."[45]

Thus, despite legislation that encouraged an interdisciplinary approach to identifying the economic, social, and environmental impacts of proposed projects, and despite critiques from the mid-1990s of use of EIA in the practice, contemporary environmental impact assessments continue to rely on quantitative data, counts and formulaic calculations, tables, and purportedly objective measures of impacts. The socio-economic assessments look at the age distributions of residents, housing statistics, income levels, job descriptions, sanitation, food supplies, lighting, and the volume of traffic on roads. In some cases, EIAs focus on the availability of housing and other resources in the area to support the employees of the proposed projects and how that will bring economic growth to the region. In all cases, they take on a very mechanistic, technical, rational character.[46] However, the displacement caused by Hanford, Chernobyl, and the proposed reactors at Jaitapur involved the rupture of family ties, broken bonds of trust, and lost connections to places that held meaning to generations of family members. Displacement involved fear of the future as well the excitement of being able to start fresh in establishing a new community. These emotions and changes in community structures cannot be adequately captured by looking at census data, by finding out how many people hold which occupations, by understanding the educational attainment levels in the area, or by knowing the population of each village and hamlet. Understanding what the local villagers requires establishing a level of trust within the communities, spending time with the people, meeting them in their places, and listening to what they have to say.

Furthermore, as indicated above, the EIA as used in practice is a one-time, event driven analysis, whereas this dissertation has demonstrated that the displacement associated with mega-projects like nuclear technology projects changes over time as the people and activities associated with the projects change. Understanding the real social impacts, like displacement, cannot be understood by a one-time count and categorization. Agencies and organizations must sit with the people affected by the projects and ask them what they feel will be the impacts of the proposed projects. They must listen, genuinely listen to their answers. And they must do so during the planning phase, the construction phase, the operations phase, and the legacy phase associated with each project.

Unfortunately, it appears that unless a recursive EIA is expressly prescribed, it will not occur. One way to overcome that bias would be to require just that type of ongoing interaction with the local communities as part of the EIA. The types of questions asked need to be spelled out—questions that begin with "What do you think?" and "How?" and "Why?" rather than just "How many?" The inquiry must not focus merely on the quantifiable and measureable, the number of people that fit into certain categories. In its "Guidelines and Principles for Social Impact Assessment," the U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service indicated that social impacts needed to include alterations in the ways people "live, work, play, relate to one another, organize to meet their needs and generally cope as members of society."[47] Furthermore, those impacts could involve "changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society."[48] Many of those impacts cannot be measured in traditional ways. They vary from place to place and over time.

NOAA underscores the importance of evaluating the social impact during Planning/Policy Development, Implementation/Construction, Operation/Maintenance, and Decommissioning/Abandonment. Survey data, comparative case studies, public meetings, scenario analyses, expert testimony, computer modeling, searches of the media for reactions to the proposed projects (including letters to the editor), and census data should all feed into a social impact analysis. In addition, based on the findings of this dissertation, any social impact analysis must involve discussions with the people most affected by the projects to understand the displacement associated with each phase.

Documentation for carrying out social impact analyses within an EIA should also identify the types of independent practitioners best suited for gathering the data. Architects, engineers, and statisticians should not be the ones attempting to understand the emotions and fears associated with the construction of new power plants in rural areas. They have not been trained for those types of inquiries. Instead, a social impact assessment needs to draw on the talents of social scientists, sociologists, anthropologists, geographers, and others whose focus in on the people and communities in the area near the proposed project.

To maintain objectivity and minimize bias in the process of collecting and analyzing data, the social impact assessment needs to be conducted by practitioners not associated with the agencies proposing the projects, those responsible for permitting or licensing the proposed projects, or even the companies hoping to benefit from construction contracts. As mentioned earlier, when conducted by government agencies or those closely allied with a project, the social assessment tends to focus on objective demographic and economic indicators, or things within their control to affect. Reaching out to skilled practitioners with no stake in the project would provide more multidimensional reports that also incorporate impacts that cannot be quantified, categorized, or looked at through a business-oriented lens. Those reports would examine potential effects on day-to-day life, social networks, people's thoughts about the future, and family cohesiveness.[49]

The revised EIA must specify that any consideration of social impacts must first occur at the beginning of the planning process and again at different times throughout the life cycle of the project, not just whenever convenient for the agencies and organizations proposing those projects. In addition, to allow the broader public to effect change in a project, input must be accepted early in the planning process, not only after the designs and decisions have been finalized. Figure 9.2 below illustrates a proposed Process Model of EIA, one that builds on the Process Model of Displacement, and one that involves the affected public right from the start. Opportunities for public input are provided throughout the life cycle of the project. The figure also shows the incorporation of the initial Social Impact Assessment (SIA) into the planning phase of a project and, at a minimum, the review of both the EIA and SIA as a project transitions from one phase of its life cycle to another, as conditions change.

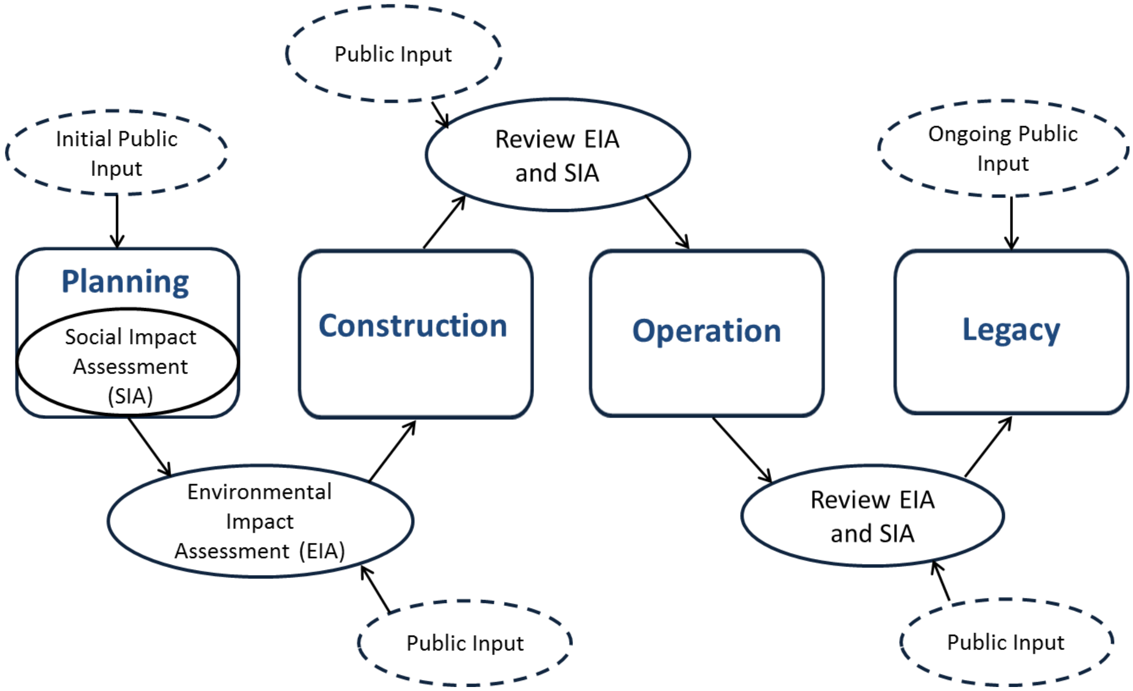

Figure 9.2 Process Model of Environmental Impact Assessment

9.3 Alternatives to Nuclear Power: An Illustration Using the Jaitapur Nuclear Power Plant

Had the Indian government and NPCIL taken the time to listen to the people of the Konkan region, the proposed location of the Jaitapur facility, they would have uncovered interesting alternatives to nuclear power for electricity generation. Advocate Baba Parulekar of Ratnagiri spoke of taking the burden off of "big" energy projects, projects that send the electricity to the big cities and leave the local communities with nothing.[50] He favored projects that would provide energy for the local communities, such as solar photovoltaic installations and small scale hydropower. Small scale hydropower could be used to generate electricity for a hamlet of about four to five houses. (At a November 2009 seminar held in Ratnagiri, Dr. Sulabha Brahme indicated small, mini, and micro hydro projects could supply

12,000 MW to the region.[51]) A cooperative movement or local society could be formed and the people educated to take care of the system, building the local skill base. Larger hydropower systems could capture the energy in the water that comes off the nearby mountains and currently flows out to the sea—that water could be captured and recycled. Some water would be stored in a reservoir and during peak periods the water would flow and generate electricity. During off peak periods, it would be pumped back up, and stored, to be reused again.

An ice supplier to fishermen on the pier at Sakharinate (also a mango farmer) suggested that the sun and wind resources available in India could provide the country with energy independence.[52] The sun shines and the wind blows almost constantly. War cannot interrupt those fuel supplies. The ice supplier also questioned why big nuclear companies chose to export their technologies to countries like India at the same time their own countries cut back on nuclear construction. The French government was a majority owner in Areva, partner in the Jaitapur project. France has plans to reduce its reliance on nuclear power from 75% of its electricity production to 50% by 2025.[53]

Those interviewed for the People's Report on the Jaitapur Nuclear Power Plant also critiqued the choice of nuclear power and suggested wind and tidal options instead.

> Use an indigenous technology for power production, why do we need to import costly technology which has already been banned in several countries because it is not ecofriendly? Why does our governtment (sic) call this a green project?[54]

In a similar vein, Amulya Reddy suggested a DEFENDUS approach to energy planning in India (<u>de</u>velopment-<u>f</u>ocused, <u>end</u>-<u>u</u>se-oriented, <u>s</u>ervice-directed).[55] Rather than the top-down imposition of favored large scale projects on communities, Reddy recommended that any consideration of energy projects start with a discussion of the goals to be achieved and the variety of resources available to meet those goals. The resources considered must also be appropriate in scale and in terms of cost. This approach would force all involved to reconsider the options for electrical generation in India, to look at the indigenous resources like solar and wind, to consider distributed generation rather than large, centralized power plants that also require a large network of transmission and distribution lines, and to ask the people of India what they want in their energy future. A DEFENDUS approach to energy planning might have identified small hydro and solar as options for India, rather than the six-reactor nuclear power facility now being contested near Jaitapur.

Precisely because of the displacement that occurs at each phase in the lifecycle of a nuclear technology project, and because of the very real emotional, psychological, and physical impacts of these and other large projects, alternatives like those just discussed must be considered seriously. Options must be examined that can achieve the same societal goals, provide the same services, but displace fewer people. Those options must be ones that—as stated in the U.S. National Environmental Policy Act--"Attain the widest range of beneficial uses of the [human and natural] environment without degradation, risk to health and safety, or other undesirable and unintended consequences."[56] Unfortunately, in the drive for economic development and the benefits of a modern lifestyle, environmental degradation, the risks associated with technology choices, and consequences like displacement have been downplayed or ignored.

9.4 Setting Bounds on Displacement

Understanding the displacement associated with entire life cycle of mega-projects like nuclear technology facilities using the Process Model, and moving towards a more participatory approach and a Process Model of an Environmental Impact Assessment and its companion Social Impact Assessment, requires understanding the size and scope population(s) to which these analyses apply. Is there a way put bounds on displacement?

As discussed in the previous chapters, the displaced associated with the Chernobyl Nuclear Power Plant included the people brought to Ukraine to build the facility, firefighters and liquidators conscripted to serve, and families in Pripyat and the villages in the exclusion zone forced to leave after the catastrophe of April 1986. The liquidators returned to homes across the Soviet Union; “Chernobylites” found new places to live in Russia, Ukraine, Belarus, or wherever they might be accepted. In addition, as long as radioactive material remains at the site, behind the fences of the exclusion zone and buried beneath the containment structure, the public will be displaced from that corner of Ukraine. At Hanford, the displacement involved those who lost their homes and land within the boundaries of the 586 square mile site in eastern Washington, people who journeyed from across the country to take jobs at Hanford, the “Downwinders” exposed to radioactive plumes from the reactors, and the populations that must avoid contact with the radioactive debris housed there for hundreds of thousands of years to come. In both cases displacement involves events that already occurred but still affect the present and the future. Displacement also extended and continues to extend well beyond the borders of the nuclear facilities and the fences around the contaminated Legacy sites.

The people near the proposed Jaitapur Nuclear Power Plant worry about their futures as fishermen and providers for their families, based on their discussions with people living and working near other reactors in India, information they have received from activists, material they have read, and due to the loss of their farms and grazing land. They fear they will suffer the same fate as the people of Chernobyl. Their displacement is rooted in the present and extends into the future. Like the displacement at Hanford and Chernobyl, the displacement is not bounded by time.

The 2007 Indian Rehabilitation and Resettlement Policy requires that those in charge of projects affecting 400 or more families living in plains areas, or 200 or more families living in Tribal or hilly areas compensate land owners for their losses. For smaller projects, the policy does not take effect.[57] The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, passed in 2013, attempted to address oversights in the earlier law, including in the definition of Project Affected People, widows, the landless, self-employed, fishermen, and small traders.[58] Land for land is included in compensation, not just money. But time will tell how it plays out in practice—amendments to the Act continue to be filed. While setting a numerical bound on the number of families or individuals affected by a project seems to make sense for mega-projects like Hanford which can result in the displacement of tens of thousands of people. However, consider the rural areas of the global south where many new nuclear projects may be sited in the future. Consider the small villages in those areas. If the populations there fall below the set threshold, are those people any less subject to displacement than the people displaced by Hanford?

For the EIA and Social Impact Analysis of the two new reactors at the VEGP site in Georgia, a 50 mile radius (80 km) circle was drawn around the site and impacts of the proposed project that fell within that circle were taken into consideration.[59] For nuclear reactor projects in the United States,

> Generally, the plume exposure pathway [Emergency Preparedness Zone] (EPZ) for nuclear power plants shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries.[60]

Thus, the planning document used this 50 mile radius in assessing the socio-economic impacts of the proposed project. This very rationalistic approach assumes that all of the impacts would be distributed within that space. In contrast, this dissertation has demonstrated that displacement depends highly on place, the situation, the people involved, and the particular sequence of events. Limiting the analysis to a 50 mile radius could potentially result in an analysis that misses key displacement-related issues. Without actually experiencing the place, wandering across the landscape, talking with the residents, and asking them about the potential impacts of a proposed project on their lives and on their communities, drawing a circle with a 50 mile radius seems rather arbitrary. Like the barbed wire marking the exclusion zone at Chernobyl that assured me on my side I was safe, but on the other side, the world was radioactive.

In the end, putting boundaries on displacement requires a great deal more research. Questions yet to be answered include, *Should* upper and/or lower bounds be established for displacement? If so, how should those bounds be set and by whom? This section suggests displacement changes over time and extends beyond man-made borders. How can those characteristics best be captured in boundaries?

9.5 Further Research

In addition to undertaking research into the questions related to putting boundaries on displacement as just mentioned, this dissertation has generated a number of avenues for further investigation. Those include:

1. Further assessment of recursive, process-based Environmental Impact Assessment and Social Impact Assessment processes independent of government agencies and independent of the companies proposing the projects under review. What would the process look like? What types of people and groups should be involved? Whose input should be solicited? How do we ensure civil society and those most affected by projects do have a voice?

2. Examination of the question: Can a recursive impact assessment occur without setting boundaries on displacement in advance?

3. Exploration of ways to ensure that people have a voice in the assessment of nuclear technology projects and other large scale or mega projects--that the process of understanding the impacts of each phase of the life cycle of these projects, and the associated costs and benefits, becomes more democratic. The U.S. National Environmental Policy Act reminded us that we must '[f]ulfill the responsibilities of each generation as trustee of the environment for succeeding generations."[61] Yet, time and time again economic benefits of proposed projects outweigh all else.

4. Application of the Socio-Political Ecology framework and Process Model of Displacement to other mega projects and other industries. This dissertation has validated the framework and Process Model in the context of three case studies of nuclear technology. Applying the Process Model to other contexts would further validate and help refine the model.

9.6 Conclusion

In drawing this dissertation to a close, I return to the arguments first introduced in Chapter 1. I assert that the analysis of displacement associated with mega projects, like nuclear facilities, has largely been event-based.[62] The examination of nuclear technologies has usually focused on technical, economic, political, and perhaps, environmental factors. I maintain that social dimensions need to be added to those examinations in a Socio-Political Ecology framework. Social dimensions appear in the form of physical and psychological displacement of people throughout the life cycle of nuclear projects, from planning through waste disposal. Understanding displacement in this context requires a framework and methodology that conceives of displacement as an enduring, evolving, open-ended process. A Process Model of displacement helps us better understand the negative consequences of nuclear technology that have occurred throughout its history, continue to occur in the present, and will need to be planned for in the future. We can no longer ignore the multi-faceted on-going displacement that occurs with mega projects (like nuclear), particularly when we have other options available to us.

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Appendix A

POLITICAL ECOLOGY, THEORETICAL FOUNDATIONS

This appendix briefly reviews the evolution of ideas about the place for technology in day-to-day life, the increasing reliance on electro-mechanical machinery, and the impact the associated changes have had on society and the environment over the last 2 – 3 centuries. It presents a brief evolution of perspectives on technology that help explain the early faith that politicians, industry representatives, and the public put in the power of the atom to bring peace to the world or to power booming economies. The appendix concludes with a discussion of Political Ecology, an interdisciplinary framework that emerged to bring together these political, economic, and environmental facets of modern technology choices.

A.1 Early Thoughts about Technology

As early as the mid-1600s and into the 1700s, during the Age of Enlightenment, scientists and scholars across Europe began to challenge the many teachings of the Catholic Church, the divine right of the kings to rule, and ideas of the world derived from observations of its regular, natural cycles. Unquestioning acceptance of religious tenets gave way to precepts based on scientific experimentation, mathematics, and rational argumentation. Ideas of "progress" became associated with using the new understanding of the world to move society toward something new and different, something better than the past. While faith still played an important role in life, it no longer sufficed. Science and logical consideration of the facts mattered. It was a time of "the progressive realization of reason" and a "glorious mental dawn."[1]

That science and technology led the way became evident during the Industrial Revolution of the 18th and 19th centuries. As Lewis Mumford reminded us, society came to prize technology to a high degree: ". . . the smoking factory chimney . . . emblem of a crude, imperfect technics became the boasted symbol of prosperity."[2] However, with the increasing reliance on technology came environmental degradation and the replacement of human skill and creativity with "human machines composed of specialized, standardized, replaceable, interdependent parts."[3] Human machines became cogs in a giant economic machine. That economic machine grew and grew, sustained first by the resources locally available and later by resources found world-wide. Efficiency, productivity, and profitability became the driving forces of change and thus of further "progress."[4]

Theorists like Adam Smith, David Ricardo, and Karl Marx foresaw the social and political implications of the emerging Capitalist economic structure.[5] They postulated that the division of labor would lead to an increasingly ignorant and de-skilled working class, at the mercy of the businesses that employed them. Power and wealth would concentrate in the hands of a few.

A.2 Political Economy

Understanding the interrelation between capitalist systems of production, distribution, and consumption; economic growth and profits; and the role played by changes in technology fell to the Political Economists. Marx and his followers explored the forces behind the expansion and contraction of economy, in both the short term and the long. Joseph Schumpeter described the cyclical nature of the capitalist market system, the alternation between periods of growth and innovation and periods of decline.[6] In his model, entrepreneurs and innovators kept businesses and the economy from stagnating or failing by introducing new products, processes, or resources. Schumpeter also introduced another factor into the market equation, a policy dimension. To dampen the ups and downs of this economic cycle, to maintain a minimum level of employment, and to provide social services to those without work, would require government intervention. Thus, in addition to the market forces, the economy could be shaped by political institutions and the laws or regulations they chose to implement.

Capitalism has spurred increases in producer and consumer choice, competition, producer efficiency, and wealth accumulation. It has also led to concerns about negative impacts that drive to produce and consume has had on the natural environment. Some scholars have responded by incorporating those impacts into their economic models. Ronald Coase's "The Problem of Social Cost," for instance, looked at the harmful effects of businesses on their neighbors and who should pay the price of that harm.[7] Rather than making the business always responsible for its noise, pollution, or other environmental and social damages, Coase argued in favor of letting the market determine the outcome: "It is all a question of weighing up the gains that accrue from eliminating these harmful effects against the gains that accrue from allowing them to continue."[8] He also cautioned the government not to interfere in the economic system, lest its actions would lead to over-protection of those responsible for the harms.[9] In the long run, protectionism would also lead to costs for solving the problem in excess of what would result from marketplace transactions.

Other scholars have attempted to more formally bring the environmental resources and impacts on the environment of business operations into the economic equation. Environmental Economists, not accepting an unfailing belief that market mechanisms will account for pollution, environmental degradation, and increasing scarcity of resources, look at the costs and benefits associated with various policies and regulations that may be used address the externalities associated with modern business practices. They examine environmental issues through the eyes of economics. Ecological Economists have questioned that market-centered approach, taking the environment and the ecosystem services it provides as the starting point.[10] Both groups try to grapple with issues related to putting monetary values on nature and natural resources.

Robert Costanza et al., for example, estimated the value per unit area of ecosystem services (defined as flows of materials, energy and information derived from natural capital stocks) for each ecosystem type, regardless of whether those services actually pass through markets.[11] While some of those services, like raw materials, are easily valued by the market system, many are not. Services not reflected in market transactions include nutrient and carbon cycling, waste filtering and decomposition, air purification, and erosion control. Costanza et al. estimated total value of market and non-market ecosystem services at $33 trillion in 1997, or almost 50 trillion in 2014 dollars.[12] By comparison, at the end of 2014, the size of the Chinese economy (as measured by purchasing power adjusted Gross Domestic Product) was estimated to be $17.6 trillion, while the U.S. economy ranked second largest in the world at $17.4 trillion.[13] Thus, the value of the services provided by nature dwarfs the size of the market economy. "We must begin to give the natural capital stock that produces these services adequate weight in the decision-making process, otherwise current and continued future human welfare may drastically suffer."[14]

Costanza et al. relied on estimates of consumer and producer surplus associated with each of the ecosystem services worldwide in reaching their startling conclusions.[15] Another method of valuation involves examining the willingness to pay (how much people would pay above the market price to obtain a given resource, to avoid depleting that resource, or to prevent damage to the natural environment in obtaining it). Valuation can also be determined by looking at the cost of replacing a resource or mitigating the damages associated with its extraction. Other economists rely on damage functions (which relate the level of an offending activity to the degree of physical impact--such as health problems--and thus to the cost of avoiding or mitigating the impact), or draw on valuations that can be derived from behaviors related to the damage or depletion, such as changes in property values that result from changes in environmental conditions.[16] All of these methods aim to put a dollar value on nature and natural processes, thus simplifying their incorporation into economic models and analyses of choices facing businesses, regulations, and consumers.

Not all Political Economists have focused their life's work on determining the monetary value of nature. Some in the discipline have been at the forefront of calls for change, particularly for a change in the belief that the economy can continue growing and growing and growing. A growing capitalist economy requires increasing volumes of resources (or more efficient use of available resources) and a growing consumer base with an insatiable appetite for newer, better, and more. In a world of finite resource availability, continual growth leads to "overshoot": exceeding the capacity of the earth to provide the raw materials demanded or to absorb the pollution and wastes, the by-products of growth.[17] For some, like Garrett Hardin, the solution to the problems of growth involved reining in the freedom to breed.[18] For others, change required policy interventions that curb excessive emissions, that mandate the use of sustainably produced materials, or that put the economy on a path to a steady state or even "de-growth."[19] De-growth would encompass producing and consuming less, using renewable energy sources, refocusing on local rather than global sources, and cooperation rather than competition, all while maintaining a quality standard of living.[20] Another group looked to the business side of the economy, and the promises of innovation and modern technology, to find solutions to current issues associated with capitalist production and consumption. Julian L. Simon and Herman Kahn concluded their critique of the rather gloomy forecasts of the "1980 Global 2000 Report to the President," initiated by President Jimmy Carter in 1977, by writing,

> Our positive statements about the recession of the physical constraints upon human progress are based primarily upon presently known progress, not taking into account possible or even likely advancements in technology. If we were to take into account such possibilities as the resource available to us in space and other such advances – even those possibilities which are already solidly worked out scientifically – our assessment would be much more "optimistic" than it is.[21]

It is that faith in technology, like the power of the atom, to solve the world's problems to which we now turn.

A.3 The Technological Imperative

As indicated above, as the focus of life shifted toward the economy, the spiritual gave way to the rational. Instead of being defined as a mere change from what had been, "progress" became associated with the accumulation of surplus goods and wealth, endless efforts to increase efficiency and productivity, and the possession of the technological prowess to make that all possible. Indeed, according to Jacques Ellul, those characteristics have become so ingrained in daily life that we no longer question them.[22] We continually use science and reason to develop new methods and new tools in a never-ending search for the most efficient, the most effective—simply the best in everything we do. Indeed, "[t]oday no human activity escapes this technical imperative." [23] Whereas people became small cogs in giant mechanical machines during the Industrial Revolution, in modern times, people devote their days to finding technical solutions to small segments of enormous technical problems. Finding a solution may create new knowledge that can be used to further advance technology. However, every technical advance also may produce unpredictable negative effects.[24] Those effects may be mitigated using other technologies, other scientific approaches. For example, scientists and engineers developed wet scrubbers, baghouse filters, electrostatic precipitators, and carbon sequestration techniques to control the emissions from energy production and industrial facilities. Absorbent booms and chemical dispersants have been created to mitigate the impacts of offshore oil spills. So technological progress continues. And, according to Ellul, that progress is irreversible.[25]

Following in the footsteps of Ellul, Byrne and Hoffman assert that the combined forces of the scientific, political, military, and industrial communities made the commercial application of nuclear power "virtually unavoidable" in the United States.[26] Its progress was irreversible. The scientific community understood how to split atoms to generate enormous amounts of energy: the military had demonstrated the value of harnessing that energy in their use of atomic bombs, to propel submarines, and to bring a quicker end to World War II. Engineers deemed it was indeed possible to use the atom for electrical generation. The Atomic Energy Commission (established by Congress in 1946) contended that developing a competitive nuclear power industry was of critical importance in maintaining the country's technological superiority and in giving the U.S. bargaining power over other nations. Thus, generating electricity using nuclear technology became the next logical step in the progression of nuclear technology.

Byrne and Hoffman also argue that "[s]topping or reversing technological development at [that] point would have required erasure of the corresponding technical knowledge," and that is impossible.[27] In general, scientific thinking and technological knowledge can move forward, building on existing ideas, but cannot be reversed. Thus, despite concerns from some in the scientific community over the safety of even low exposure to radiation; despite the apprehension of insurers that the new use of the atom was too risky for their backing (the government stepped in with the Price-Anderson Nuclear Industries Indemnity Act of 1957 to ensure those investing in nuclear technology could find insurance backing); despite a lack of design or safety standards for the burgeoning technology (those developed piece-meal over the ensuing decades); and despite firm estimates of the extremely high potential costs of the undertaking; the nuclear power industry in the United States emerged. As the technology spread across the country and worldwide, it became yet another symbol of progress, of an "advanced" civilization.

In his book about the catastrophe at Chernobyl, Gould describes a place occupied by both electrical engineers and atomic engineers. Unfortunately, each group stayed in its particular box, unable (or unwilling) to grasp the specialized knowledge of the other. "The trouble with science and technology today is that the sheer volume of knowledge is so enormous that no one can possibly grasp more than a small part of it. The result is ever-higher degrees of specialization, with more and more people . . . increasingly disconnected from the rest."[28] Gould proposes that the disconnect evidenced at Chernobyl was just one example of a larger, global problem. "And there is no escape."[29]

In a similar vein, Willem H. Vanderburg maintains more generally that members of modern society have become so caught up in the technological world and so specialized in our knowledge that we have lost our understanding of the larger world and our place in it.[30] We have become detached from our natural environment, detached from the source of the energy that powers our daily life, and detached from other people in our lives. Witness the ear-bud wearing, cell phone scanning commuters who never interact with their fellow commuters on the train that intones "Have a nice day!" as they depart at the appropriate station. Our common sense has become "non-sense."[31] Unfortunately, "[e]volving human life and society on the basis of non-sense could close off a genuinely human future . . ."[32] Furthermore, two powerful allies--corporations and the state--back the system of non-sense. Breaking free from this grip of economic forces and technology requires making different choices--choices that will help us regain the sense of our situation and challenging the dominance of science, rationality, and technology. We must question the current definition and direction of progress.

A.4 Moving Beyond Traditional Capitalism

Among those who have questioned the direction of progress are Amory Lovins and his followers. They began to examine the toll that a century of progress has taken on the natural environment and proposed a different way of looking at the economy, referred to as "Natural Capitalism." Whereas traditional capitalism focuses on financial and manufactured capital at the expense of the human and natural, Natural Capitalism recognizes the need for four different kinds of capital inputs into a production system: Human (labor and intelligence), financial, manufactured (infrastructure and machines), and natural (resources and ecosystem services).[33] Going one step beyond attaching a monetary value to environmental resources, a Natural Capitalism approach involves more efficient and effective use of all the resources, investing in stocks of natural capital to help reverse the past destruction, and the shift to a "service and flow" economy in which the *services* provided by goods are bought and sold, not necessarily the goods themselves. While Natural Capitalism recognizes the importance of human capital, it does so in terms of beneficial employment and the increase in their well-being through the receipt of services. It does not address the explicitly disruptive effects capitalism and even the preservation of natural capital can have on elements of society.[34]

Those interactions among economies, people, and nature lie at the core of ideas of ecological justice. Ecological *in*justice results from exploitation of resources by groups far removed from the harmful effects of that activity. That happened during the colonization of Africa, India, and South America by European nations and continues to occur as the world-wide pressure to find new sources of foodstuffs and fossil fuels. Ecological justice, on the other hand, recognizes the value of the voice of the local people. It gives as much weight to traditional knowledge, based on generations of experience with the land, as to Western science. It considers the needs of future generations and not just the present ones.

André Gorz also insisted on taking future generations into account in current decision-making.[35] "[O]ur present mode of life is without future . . . our world is ending . . ."[36] He suggests we must break with economic rationality. We must begin to realize that it is in our best interests to use less, to scale back, to conserve natural resources rather than exploit them. Rather than relying on large, domineering, central governments to make decisions on behalf of a large populace, Gorz called for a return to self-management, for the re-development of smaller scale systems of exchange and interaction that can respond to local needs and preferences.[37] Like the advocates of ecological justice, Gorz supported a more localized focus.

The roles of local people, of civil society, and the state in choosing and supporting particular technologies reflect some of the political dimensions of technology and technology choices. Langdon Winner proposed a theory of "Technological Politics" to draw attention to this political character of technology.[38] Like Ellul, Winner acknowledged that society responds to technological imperatives and that technology shapes both human behavior and society as they adapt to it. However, Winner argued that technology also is inherently political, with "politics" defined as the arrangement of power and authority. In some cases, the choice, design, and arrangement of technologies may be used to settle an issue in a community. In rural New York, for example, overpasses on scenic parkways were deliberately constructed at a height too low to allow busses or large trucks to pass under them. The overpasses then dictated which vehicles could use the parkways.[39] In more modern times, speed bumps, islands, roundabouts, and "red light cameras" installed on roadways aim to slow the flow of traffic through neighborhoods. Winner also explained that in other cases, the technologies themselves are "inherently political," that is, they align more closely with particular political arrangements. Particularly germane to this research is the fact that nuclear power is often associated with authoritarian, centralized power systems—like that in the former Soviet Union at the time of Chernobyl's construction-- due to its large up-front capital requirements, the length of time it takes to design and construct a new nuclear power plant, the need for government backed insurance programs , the large amount of electricity generated, and the government subsidies required to make the electricity produced competitive with other sources of electricity in the marketplace.

In the end, Winner argued that even politicized technologies and their consequences for society must be understood within a larger context that includes the history of the technical systems, the actors who influence the design and arrangement of technologies, and the patterns of power and authority that affect the particular choice of technology. Thus, while we may often seem predisposed to turn to technology in modern life, we must also recognize that other facets of modern life affect and are affected by technology choices: the natural environment, the economy, political systems, and human beliefs, values, and cultural systems.

A.5 Environmental Thinking

While Environmental and Ecological Economists have tried to quantify the contribution of nature to the market economy (Section A.2), that has not been the only focus scholars interested in nature. In the centuries after the Enlightenment, many turned their attention to understanding the natural world, natural processes, and the creatures found in nature. In 1843, William Prescott Joule introduced the First Law of

Thermodynamics, the conservation of energy: within a closed system, energy can neither be created nor destroyed, only transformed from one form to another. Augustinian Friar Gregor Mendel laid the foundation for the science of genetics with his studies of pea plants in the 1850s and 1860s. Also in the 1850s, Charles Darwin laid the groundwork for a rational, field-based approach to an understanding of the world and of the place of mankind in it.[40] His *The Origin of the Species* broke with the tradition that had posited humans as a separate, morally superior species. Instead, he argued in favor of an interconnected ecological community of which mankind was just one part. With the invention of the microscope and development of scientific laboratories, scientists like Louis Pasteur uncovered the tiny germs that led to the decay of liquids and solids, and to diseases in human beings. And in 1898, Marie Curie discovered polonium and radium and proposed a theory of radioactivity, proposing that radiation actually came from within and not from any interactions between atoms.

Scientific discoveries and inventions continued on into the new century. At the same time, increased industrialization, urbanization, the spread of railroads and automobiles all helped shift the focus toward conservation and preservation of the environment and resources. President Theodore Roosevelt spearheaded that movement in the U.S.:

> We have become great because of the lavish use of our resources. But the time has come to inquire seriously what will happen when our forests are gone, when the coal, the iron, the oil, and the gas are exhausted, when the soils have still further impoverished and washed into the streams, polluting the rivers, denuding the fields and obstructing navigation.[41]

Roosevelt oversaw the protection of approximately 230,000,000 acres of public land during his tenure in office.

Those early conservation efforts led to the development of ideas of the scientific management of those monumental tracts of public land, found in the works of Gifford Pinchot, Aldo Leopold, and others.[42] Scientific management applied Frederick Taylor's ideas of rationality, decisions based on empirical analyses, efficiency and elimination of waste, and the standardization of best practices to natural environments. For example, under Pinchot, the leader of the nascent U.S. Forest Service, valuable forests in the western U.S. were spared from widespread destruction for purely private economic purposes, and instead fell under a regime of "wise use" that would allow them to thrive well into the future and thus provide "the greatest good for the greatest number" (an idea that eventually became known as "sustainable yield" in fisheries and forestry).

Preservationists, in contrast, wanted nature and natural resources to be set aside, not used for strictly human purposes. Rather than allow the land to be used for timber production or animal grazing, John Muir fought to save the Yosemite Valley and the newly created Yosemite National Park, to protect ecosystems from damage. Preserved lands could be used in the advancement of science, as wildlife sanctuaries, for educational purposes or recreation or scenic enjoyment, but not for resource extraction. Aldo Leopold also advocated a less business-like approach to the bounty of nature. He advocated in favor of the nature as one part of a broader "community" which also included people and--what he termed a "land ethic":

> The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals . . . A land ethic cannot of course prevent the alteration, management, and use of these

> ‘resources,’ but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state.[43]

In areas not set aside as national parks, national forests, or wildlife preserves, expanding industrialization and growing populations led to increased levels of pollution and increased concern about the impacts. The Great London Smog of 1952 that killed thousands led the British government to enact its first Clean Air Act in 1956. The first American Air Pollution Control Act took effect in 1955. The regulation of water pollution followed in the 1960s. Organizations of concerned citizens such as the Nature Conservancy, the World Wildlife Fund, and Friends of the Earth also got their start during those decades.

The intense production-oriented management of both public and private lands following World War II, and particularly the widespread use of synthetic chemical pesticides, came under intense scrutiny after the 1962 publication of Rachel Carson’s *Silent Spring.*[44] Carson admonished scientists for not having a better understanding of the harm they were now inflicting on the natural world through the products they helped create. She called on science to take part in setting the policies that would help rein in the damage mankind was inflicting on the environment. In a sense, she also called into question the technological imperative as applied to nature. Should we be manipulating the environment using chemicals to help meet the demands for more, more, and better corn, rice, wheat, and other foodstuffs?

In 1970, Americans observed the first Earth Day, a citizen’s movement aimed at setting aside time to reflect upon the state of the earth and to engage in projects oriented toward improving its lot. The same year, President Richard Nixon established the U.S. Environmental Protection Agency (EPA) to set standards and oversee the enforcement of environmental protections.[45] The Clean Air Act passed in 1970, setting national air quality, auto emission, and anti-pollution standards. Stringent standards on other pollutants in the air and in water followed in the ensuing years. In their wake came a raft of new ideas and technologies, such as catalytic converters that could clean the toxins out of vehicle tail pipe emissions, and low solvent powder paint coatings. Managing the environment had become a political and industrial as well as a scientific undertaking.

The close association between science, policy, and industry on environmental issues was evident in the 1980s when scientists identified industrial emissions as a key contributor to “acid rain”: the precipitation of sulfuric and nitric acids that have formed from the reaction of sulfur dioxide and nitrogen oxides from fuel burning with water, oxygen, and carbon in the atmosphere.[46] Acid rain destroyed forests and crops, ate away at statuary, and corroded metals. To combat the problem, the U.S. Environmental Protection Agency implemented a market based emissions trading scheme that capped the emissions allowed and required coal burning power plants and other large polluters to buy and sell emissions allowances. The emissions cap decreased over time, forcing the industries to install the best available pollution control devices, to install less polluting equipment, or to switch to cleaner burning fuels.[47]

More recent concerns have turned toward the impact of carbon dioxide, methane, and other greenhouse gas emissions on climate. These gases absorb and emit thermal infrared radiation, effectively trapping it in the earth’s atmosphere. The resulting changing climatic conditions threaten the environment as we know it with changes in rainfall patterns and temperature, and in the severity of droughts and storms. With those can come alterations in the mix of animal and plant species that can and will coexist in particular regions of the globe. Climate scientists, botanists, biologists, chemists, ornithologists, and oceanographers have been key to understanding the changes that have occurred to date and helping industry representatives, policy makers, and the general public appreciate the magnitude of the challenge that lies ahead.[48] New businesses emerge to meet those challenges, developing products like solar powered charging stations for electric vehicles, energy efficient light emitting diode (LED) bulbs, or renewable fuels for jets made from algae. In sum, business and industry, politics and policy, science and the environment intersect in responding to and managing life in the modern age.

A.6 An Interdisciplinary Framework for Understanding: Political Ecology

The question then becomes: How can we incorporate business, technology and economics; political dimensions; environmental justice/injustice; and the complexity of global and local environmental concerns into one framework that can be used to guide understanding the complex interactions and to support decision-making in the modern world? Few theoretical perspectives capture the totality of factors that really impinge on choices about technology and even fewer try to tackle one of the impacts of many of those decisions.

As indicated earlier, economic analyses explain only those facets that can be valued in an economic sense, can be quantitatively modeled, and/or are traded in a marketplace. More specifically, institutional investors, utilities, and electricity generation companies often use levelized cost analyses to compare the cost per kilowatt-hour of various options for producing electricity. Return-on-investment (ROI) calculations reflect the amount of money invested in a project relative to the income stream it generates. Public sector investors often use benefit-cost analyses to determine if projects should be undertaken, and, given a choice of projects, which would be preferred. The monetized expected benefits (such as health care costs foregone by reduction in air pollution) are compared to the expected costs, at an assumed interest rate. Although all such economic analyses can provide guidance on investment decisions, or may explain the choice of one option over others, the results depend significantly on the underlying assumptions, the values chosen for different variables, and which factors researchers, investors, or analysts include or do not include in the analyses.

Ecological and environmental economists, like Coase, Costanza et al., Dixon et al., and others, do try to incorporate environmental attributes into their models. However, they do so by attaching a market value to the goods and services provided by natural ecosystems or to the actions needed to be taken to prevent harm to those ecosystems.[49] While better than purely economic analyses, these approaches do impose rational, linear, bounded ways of thinking on environmental systems, and may not capture interactions, feedback loops, or other complex elements.

In addition, economic models only secondarily capture the risk associated with investments in technology, either through the impact of perceived risk on interest rates for borrowed money, or through the level of government subsidies needed to make new technologies economically competitive with the old. However, risk may be a more integral part of technology choices than that. Beck's "Politics of a Risk Society" asserts that we rely on technologies whose hazards are not known with certainty, whose potential side-effects cannot be estimated in advance of their use.[50] We trust in science to minimize the risks and in regulatory bodies to devise laws to control the known risks. We believe scientists and engineers can reduce the risk of a core damaging event at a nuclear power plant to just 1×10^{-7} per year.[51] According to Beck, society has become a large science laboratory where absolutely nobody is in charge and nobody takes responsibility for the outcomes. Additionally, we may not be able to imagine and plan for every possible contingency, every potential risk-inducing situation, as was demonstrated when the tsunami hit the Fukushima Dai-ichi nuclear facility in March of 2011, crippling the reactors and inundating the back-up power systems. The reactors at the plant shut down automatically, as planned, when a magnitude 9.0 earthquake shook the region the afternoon of March 11, 2011. However, all external power supplies to the site were lost and access roads were damaged. Two 14 – 15 m tsunami waves then over- topped the 10 m man-made sea walls, submerging the pumps for the backup cooling circuits and the residual heat removal cooling system, flooding the spare diesel generators, electric switchgear, and batteries. [52] An industry that prides itself on being able to calculate the probabilistic risk of a core meltdown to five to seven decimal places suddenly found itself faced with the actual risk of a core meltdown closing in on 1.0.

Political Ecology can shed light on the many interconnected dimensions of technology choices, including risk, economics, the associated policies, natural resource availability, and even the ultimate impact of technology on natural resources. The term Political Ecology first emerged in the 1970s as people became increasingly aware of how highly politicized the natural environment had become.[53] Cockburn and Ridgeway, in their 1979 anthology, *Political Ecology*, defined Political Ecology as a "way of describing the intentions of radical movements in the United States, in

Western Europe, and in other advanced industrial countries."[54] Regarding the activism that had grown up to oppose nuclear power plant construction, they wrote:

> While the issue of energy was the central question, more profound was the gradual realization of all the various groups within the movement . . . that the word "ecology" implies the indivisibility of total systems, and that all their disparate concerns were connected . . . Hence has arisen the term "political ecology". . .[55]

Cockburn and Ridgeway described Political Ecology as an exploration of the conflicts between people, their productive activities, and nature, and the influence of cultural and political activity on all three. That first volume set the stage for the diversity of ideas that have become "Political Ecology".

Political Ecology was further refined in the 1980s and 1990s as scholars in geography and anthropology examined the politics of access to and control over natural resources, and environmental change. Blaikie and Brookfield, in 1987, and Greenberg and Park, in 1994, identified Political Ecology as a synthesis of political economy (concerned with the distribution of power and productive activity) and ecological analysis (which examined bio-environmental relationships).[56] Hempel (1996) further narrowed the scope of Political Ecology as being ". . . concerned with the political consequences of environmental change."[57]

Perkins *Geopolitics and the Green Revolution* expanded on the notion of productive activity, identifying a place for technology in the Political Ecology equation: The choice of technology mediates between human wants and needs and the natural environment and natural resources.[58] Although Perkins originally used this idea to explain the drive to increase crop yields and the evolution of farming into a global agri-business, the concepts can also be applied to an industry that must respond to people's demand for electricity while at the same time searching for ways of generating electricity that have less of an impact on the natural environment. Concerns about the greenhouse gas emissions from burning fossil fuels, for example, have led to support for solar photovoltaics and wind generation. The European Commission has set binding targets of increasing the share of renewables (wind, solar, geothermal, hydro, and sustainable biofuels) in the energy mix to 20% by 2020 and at least 27% by 2030.[59] In the U.S., 29 states and Washington D.C. had binding renewable portfolio standards (RPS) that specify a certain percentage of electricity sold on the retail market must come from renewable sources. Another nine states have non-binding RPS goals.[60] In these cases, the demand for electricity is the human want or need in Perkins' Political Ecology model, greenhouse gases and climate change represent the environmental aspect, and the technologies under consideration are those that generate electricity without producing carbon dioxide. All of these appear against a backdrop of policy requirements that dictate cuts in emissions or the use of certain types of technologies.

Thus, in the context of renewable energy technology decisions, Political Ecology can underscore the relationships between economic factors (such as subsidies, levels of capital investment; the need to generate profits or achieve a specified return on investment); concerns about the safety or risk associated with a particular technology; natural resources (including the availability of coal, natural gas, petroleum, wind or solar resources, as well as the impact that coal mining or oil extraction have on the environment); available technologies; and the political and policy climate that affects and may be affected by all of those factors.[61] These factors are shown in Figure A.1 below for the particular case of decisions about energy technologies.

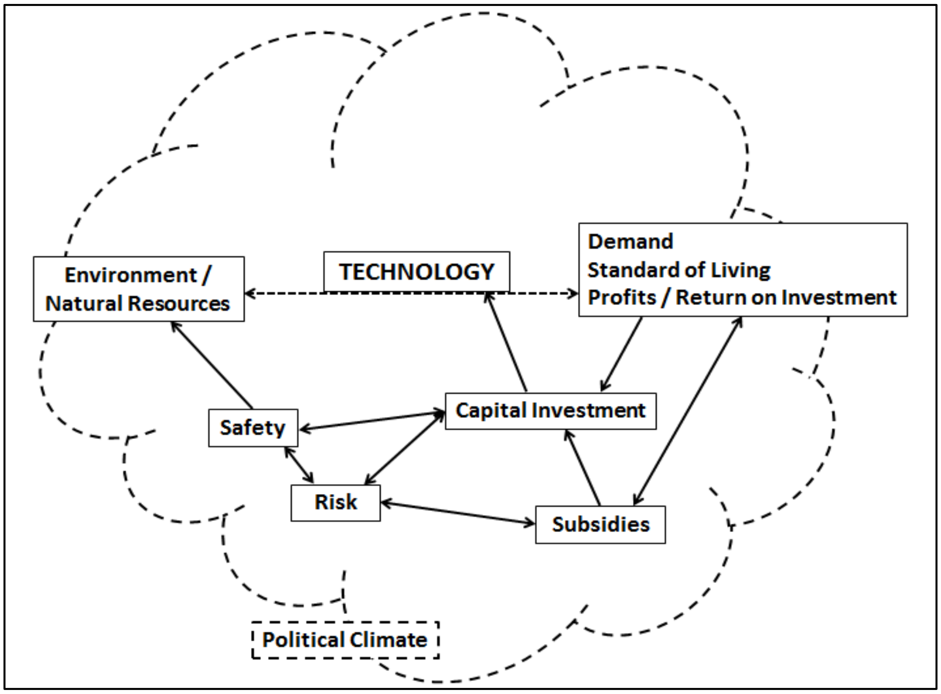

Figure A.1 The Political Technology of Energy Choices

Unfortunately, as argued in the main text of this dissertation, the Political Ecology framework fails to take into account an important factor that affects and is affected by technology decisions: people. Chapter 2 explores in more detail the expansion of the Political Ecology framework to incorporate that social dimension and looks one particular social impact: the displacement that occurs when the decision is made to build large nuclear technology projects. Chapter 3 then expands on displacement, broadening the concept from a one-time movement of people and their belongings to one that can occur over time and can incorporate emotional, psychological, and physical dimensions. Political Ecology then becomes a Socio-Political Ecology framework that brings people and the impacts on people into decision-making.

ENDNOTES

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[6] Joseph A. Schumpeter, *Capitalism, Socialism, and Democracy* (New York, NY: Harper and Row, 1942), 87 – 106.

[7] Ronald Coase, "The Problem of Social Cost," *Journal of Law and Economics* (October 1960): 1 – 44.

[8] Ibid., 26.

[9] Ibid., 28.

[10] Robert Costanza, "What is Ecological Economics?" *Ecological Economics*, 1 (1989): 1 – 7.

[11] Robert Costanza et al., "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, 387, no. 6630 (May 15, 1997): 253 – 260.

[12] Ibid., p. 259.

[13] Mike Bird, "China Just Overtook the US as the World's Largest Economy," *Business Insider*, October 8, 2014, from http://www.businessinsider.com/china-overtakes-us-as-worlds-largest-economy-2014-10.

[14] Costanza et al., 259.

[15] Consumer surplus is the gain or loss accruing to the consumer as a result of the difference between what they are willing to pay for a good or service and the market price (what consumers actually pay). Producer surplus occurs when the supplier can sell the good or service for a price that exceeds the minimum price they will accept for that good or service.

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[32] Ibid., 462.

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[37] Ibid., p. 40.

[38] Langdon Winner, *The Whale and the Reactor* (Chicago, IL: University of Chicago Press, 1986).

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Appendix B

THE CASE STUDY AS A RESEARCH METHODOLOGY

Robert K. Yin, prolific author of books and articles about case study methods, describes a case study as qualitative research of a limited number of subjects or phenomena using ethnographic, participant observation, and other "in the field" techniques.[1] Unlike laboratory experiments which isolate the subject and vary only one factor to measure its effect on a specific outcome, case studies seek to explore many factors, to understand the entire context and the interplay of the myriad of factors at work.[2] Other authors take a slightly different view of a case study, defining it as research of a focused, spatially bounded phenomenon that uses contextually rich data from circumscribed real world settings.[3] Some narrow the definition even further, defining case studies as investigations of just a single instance or example of a phenomenon.[4] Regardless of the specifics of the definition, most authors agree that case studies need to involve many sources and types of information, both qualitative and quantitative.

Drawing on the work of these and other authors, this research defines a case study as an in-depth analysis of a phenomenon or phenomena, using a variety of data sources. As such, a case study can involve archival, historical, and time series research, surveys, interviews, and direct observations, all of which contribute to the understanding of a phenomenon or entity. In addition, a case study must examine the context of as well as characteristics of the entity itself. For this research, Hanford, Chernobyl, and Jaitapur are viewed as stand-alone entities, each with a unique context and place in history, but which together can contribute to knowledge about the relationship between the choice of nuclear technology and the displacement of people.

As with other methods, case study research usually begins with a review of the literature and a clear definition of the research question. George and Bennett describe this phase of research as "soaking and poking"—getting immersed in the existing information about the phenomenon and its context.[5] Gaps in the literature, inadequacies, or contradictions therein then inform the development of the general research question. Here, the lack of attention to the displacement of people associated with nuclear technology led to the research question presented earlier: What can be learned from Hanford, Chernobyl, and Jaitapur that might be useful in understanding nuclear technology-induced displacement and for informing future decisions regarding the use of other energy production technologies that may involve "dis-placing and re-placing" populations?

Eisenhardt suggests researchers ask themselves questions like "What am I learning?" and "How does this information differ from what has been recorded?" as they proceed with their case studies.[6] The answers to these types of questions can help them uncover emerging themes, as well as similarities and differences among the various types of data gathered. Eisenhardt's approach emphasizes one characteristic that sets case study research apart from other forms: case study investigations can evolve as they progress. Questions, constructs, and even the choice of cases can, and should, be refined as more and more information is gathered. Additions or deletion of data can invalidate traditional statistical analysis but are welcomed in case study research where the focus is on in-depth understanding rather than pure hypothesis testing. In this research, for example, a 2010 study of the social impacts of the proposed Jaitapur nuclear complex completed by students of the Tata Institute of Social Sciences (TISS) led to an interview with Makesh Kamble of the Tata Centre for Disaster Management, who oversaw the project.[7] Although raw data are no longer available, conclusions of the study will be used as a point of comparison for what was uncovered during interviews and focus groups conducted in the Jaitapur area by the author in March 2015

B.1 Advantages and Disadvantages of Case Study Approaches

The small sample size, commonly denoted "N", is the one drawback of case studies cited most often. Statistical analyses depend on large N to drive confidence levels and assist in the rejection of null hypotheses. However, the type of questions asked and type of data collected in case study research may not be amenable to statistical analyses. In fact, the size of the sample is of less concern than the quality of the information gathered. Case studies aim for an in-depth understanding, not statistical proof of a relationship between variables. This research, for example, aims to explore nuclear power projects in their complex contexts rather than in isolation or in laboratory-type conditions. No attempt is made to measure only a number of quantifiable characteristics related to the phenomena of interest. Because of that, for this dissertation, the three carefully chosen cases are considered a large enough sample for the exploration of the displacement caused by the use of nuclear technology.

Authors such as Rowley and Yin advocate the use of case studies for this type of exploratory research but not for theory testing per se. That advice applies to theories that address causality, those that specify that a given variable or set of variables leads to or causes a particular outcome.[8] However, theory can also offer an explanation of how one variable affects another or why a particular outcome ensues, as does the theory that supports the new Socio-Political Ecology model presented in this dissertation. For explanatory rather than causal theory, case study research can be superior since it includes multiple sources of data for each case and many observations, rather than a small number of measurements of only one or two variables. Indeed, case study researchers examine the complex interplay of factors, some of which may not be easily measured or even categorized, like a person's sense of place or attachment to the home in which they have lived their entire life. In fact, because it draws on multiple sources and many observations, case study research may uncover instances that run counter to what would be expected based on theory, perhaps leading to a revision of that theory.[9]

Even when used for exploratory research, case studies, like all good research, must be theory driven.[10] Theoretical grounding convinces others of the value of the findings.[11] As demonstrated in the main text of this dissertation, this research has been driven by theory, and, more specifically, by perceived gaps in the existing Political Ecology framework and the displacement literature. Political Ecology underscores the interrelationships between economic factors, concerns about the safety or risk associated with a particular technology, natural resources, available technologies, and the political and policy climate that affect technology choices. However, it overlooks the social dimensions of those choices. In particular, traditional Political Ecology fails to incorporate ideas of ties to the land and the displacement of people that often accompanies the development of modern technology. Likewise, the literature has viewed displacement as something that occurs at one point in time—when people and their belongings move to a new place, rather than something with psychological and physical dimensions that can occur across many stages of a project.

This research then aims to fill gaps in the Political Ecology and displacement literatures.

Being theory driven does not constrain case study research, however. As Eisenhardt explains and as mentioned above, the overlap of data gathering and analysis in case study research allows researchers to make modifications in the choice of cases, in the questions asked, or the type of data collected as research progresses.[12] Thus, researchers must be flexible and open to retracing their steps and revising. After all, case study research does not operate in a world of "ceteris paribus"—all else being held constant, all else being equal. Case studies research is fluid and flexible. Thus, while Appendix C outlines a variety of questions that initially guided this research, more questions arose as the research proceeded. For example, in the villages near the Jaitapur project, the responses to initial interview questions about whether or not families received compensation for their land led to further inquiries about who in a family received the funds and what they did with money, as well as the impact of the compensation schemes on the local villages.

Critics of case study research contend that the selection of the cases to be examined is biased—cases are not chosen randomly.[13] In contrast, Eisenhardt maintains that the purposeful choice of cases can constrain extraneous variation, to ensure basic similarities between cases.[14] Some cases may be chosen because they represent extremes of the entity under study.[15] For this dissertation research, the choice of the three examples of the displacement associated with nuclear technology eliminates the possibility that the differences in technology will affect the findings about displacement. The choice of three different points in time and in three different countries will allow for comparisons across time and place: Are there similarities between the displacement associated with the planning for Jaitapur and what occurred decades earlier at Hanford? Fences surrounding the Hanford site, the exclusion zone at Chernobyl, and now going up at Jaitapur provide very visible reminders that most people must "Keep Out." Have those fences had the same impact on people's displacement? Additionally, rather than clouding the comparisons with variables not taken into account in the study, the inclusion of locations in three different countries actually helps underscore the potential role of the political context in understanding displacement associated with nuclear technology. In the 1940s, the United States was at war when Hanford was constructed to supply plutonium for the secretive Manhattan Project. The Modi government in India views nuclear power as a cornerstone for the development of his country.[16]

Granted, the deliberate choice of cases based on some common characteristics does mean the cases will necessarily underrepresent a wider, more diverse population.[17] However, the primary aim of this dissertation research is not to understand the impact of all energy technologies and all types of displacement. Instead, the goal is to understand and describe nuclear technology-induced displacement in depth, to explore the rich detail present in the data, and to determine if the new Socio-Political Ecology model helps explain the findings. A second goal is to try to discern if those learnings can be used to appreciate the displacement that might be associated with other energy production technologies. In the end, how can the findings of this research help ensure the more complete incorporation of social impacts—such as displacement--into future decision-making regarding the choice of energy production technologies?

Some critics of case study research contend that the data also lack the independence required in statistical sampling.[18] However, for most case study research, independence is not an issue. Scholars choose cases to fill a gap in existing theory, to provide extreme examples of phenomena, to explore intricate relationships found in real world situations. Cases can be chosen to expand on lessons learned from earlier case studies or to search for the "Why?" behind relationships uncovered using other research methods. Thus, independence of the data points is not a prerequisite for case study research. For these three cases in particular, despite the miles between them, finding that information about dealing with the local people at one site had been used to inform policy at another would be an interesting discovery, not a worrisome indication of the lack of independence of the cases.[19]

The validity of using case studies for data gathering also has been criticized. Construct validity refers to how well the chosen constructs measure what they are supposed to measure.[20] In the context of this research, the questions may arise "How do you operationalize displacement?" and "Can you really measure displacement?" Because of the exploratory nature of this research, no attempt was made to gauge the extent of displacement, to examine the frequency of displacement, to count how many people were or were not displaced, or to create an index of the severity of the ramifications of displacement. The research has as its focus whether or not displacement occurs in association with the various life cycle stages of a nuclear power project, and what impact it has had on people.

For research into causal relationships, the *internal* validity of a conclusion drawn from data reflects the extent to which researchers can accurately state that the variables, conditions, or factors examined caused the outcome, or preceded it in time.[21] No other explanation is possible. *External* validity involves establishing the type of situations or entities to which the results can be generalized. Confounding or unmeasured variables, changes over time not taken into account, learning, and changes in accuracy of measurement can all affect internal and external validity. George and Bennett argue that case studies can achieve high *construct* validity because the researchers can identify and assess the specific concepts or factors they hope to explore.[22] In experiments or statistical analyses, researchers may also be forced to create categorical or ordinal variables or may combine several variables into one "measure" for testing purposes. Case study researchers have a great opportunity to examine a myriad of factors that could impact a given outcome--not just one or two variables. They can easily incorporate interactions and interdependencies into their analyses. Case study researchers often use multiple data sources and can triangulate to determine the consistency of information gathered. As a result, case studies can indeed achieve all three types of validity.[23] In the end, the validity of case study research, like all other types of research, depends on the careful choice of constructs, appropriate research design, and rigorous data collection.[24]

As indicated in the preceding paragraphs, case study research proves valuable for close, in-depth understanding of a phenomenon or entity of interest. It is particularly useful for topics not amenable to other research methods. Case studies can help uncover what happened and why or how it happened. In the context of this dissertation research, the case study approach been used to uncover the facts surrounding the removal of native peoples from their traditional fishing grounds and responses of transplanted construction workers and engineers to life in eastern Washington on the outskirts of Hanford. The cases study approach helps combine the statistics surrounding the evacuation after the Chernobyl accident with stories of why some residents chose to return to contaminated villages to live out their lives. The approach also reveals why the Hindu and Muslim villagers have banded together to fight the construction of the nuclear power plants at Jaitapur. While the use of a small number of case studies cannot contribute to understanding the statistical differences between the sites or events of the displacement occurring there, they do furnish a rich, complex narrative that brings to life the phenomenon of displacement due to the choice to use nuclear technology.

That narrative allows readers to experience the event or to appreciate the phenomenon or entity vicariously, through the researcher's and interviewees' words and illustrations.[25] Readers can be transported back in time or visit places they might not be able to do otherwise—to the deserts near Hanford in the 1940s, to north central Ukraine in 1986, or to present day Maharashtra, India. A clear, detailed narrative can also allow readers to reach their own conclusions about the information uncovered and to decide for themselves if the data fit the theory.

ENDNOTES

[1] Robert K. Yin, *Case Study Research: Design and Methods* (Thousand Oaks, CA: Sage Publications, 1984), 11 – 15.

[2] Roger Gomm, Martyn Hammersley, and Peter Foster, *Case Study Method: Key Issues, Key Texts* (Thousand Oaks, CA: Sage Publications, 2000), 3; Mary S. Morgan "Case Studies: One Observation or Many? Justification or Discovery?" *Philosophy of Science* 79, no. 5 (December 2012): 668 – 670.

[3] M. Barratt, M, T. Y. Choi, and L. Mei, "Qualitative Case Studies in Operations Management: Trends, Research Outcomes, and Future Research Implications," *Journal of Operations Management* 29, no. 4 (2011): 329 – 342; John Gerring, "What is a Case Study and What is it Good For?" *American Political Science Review* 98, no. 2 (May 2004): 341 – 354.

[4] Harry Eckstein, "Case Study and Theory in Political Science," in *Handbook of Political Science*, ed. F. I. Greenstein and N. W. Polsby (Reading, MA: Addison-Wesley, 1975).

[5] Alexander George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge, MA: MIT Press, 2005), 89.

[6] Kathleen M. Eisenhardt, "Building Theories from Case Study Research," *The Academy of Management Review* 14, no. 4 (October 1989): 538 – 539.

[7] Mahesh Kamble, *Perceptions Matter: People's Report, Social Impact Assessment of the Jaitapur Madban Nuclear Power Plant* (Mumbai, India: Tata Institute of Social Sciences, August 15, 2010). Interestingly, this report was deemed "unscientific" by the Nuclear Power Corporation of India Limited (NPCIL) because much of it was a compilation of people's opinions. ("TISS report not scientific: NPCIL." *The Hindu*, January 10, 2011, http://www.thehindu.com/news/national/tiss-report-not-scientific-npcil/article1076123.ece).

[8] Stanley Lieberson, "Small N's and Big Conclusions: An Examination of the Reasoning in Comparative Studies Based on a Small Number of Cases," *Social Forces* 70, no. 2 (December 1991): 309 – 312.

[9] Morgan, 670.

[10] Jennifer Rowley, "Using Case Studies in Research," *Management Research News*, 25, no. 1 (2002): 19; Morgan, 671.

[11] Robert K. Yin, "Case Study Methods," in *The Handbook of Complementary Methods For Research in Education*, ed. J. L. Green et al. (Washington D.C.: American Educational Research Association, 2006), 6.

[12] Eisenhardt, 539.

[13] George and Bennett, 24 – 25.

[14] Eisenhardt, 533 – 537.

[15] Karina Kielmann, Fabian Cataldo, and Janet Seeley, *Introduction to Qualitative Research Methodology* (London: Department for International Development, December 2011), 21.

[16] Makarand Gadgil, "PM Narendra Modi Wants Nuclear Power Capacity to be Tripled: Modi Reiterates that Energy Security is the Critical Driver of Rapid and Sustained Long-Term Development," *Live Mint, Hindustan Times*. July 21, 2014, http://www.livemint.com/Politics/vqSkbdMVwYA2BqybcTmHIK/PM-Narendra-Modi-visits-Bhabha-Atomic-Research-Centre.html.

[17] George and Bennett, 30 – 33; "Case Study Methods", 7.

[18] George and Bennett, 38.

[19] Indeed, spies from the Soviet Union stole American secrets pertaining to the Manhattan Project and copied the layout and building designs for many of the associated installations. Those types of understandings help enrich understanding of similarities and differences between the subsequent trajectory of nuclear power in the two countries. (Kate Brown, *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters* (New York: Oxford University Press, 2013)).

[20] Rowley, 20; Mario F. Triola, *Elementary Statistics* (New York, NY: Pearson Addison Wesley, 2006), 94.

[21] Rowley, 21.

[22] George and Bennett, 19.

[23] Lieberson, 312 – 314; “Case Study Methods”, 10; Morgan, 674.

[24] For an interesting discussion of evaluating the quality of qualitative research, see Sarah J. Tracy, “Qualitative Quality: Eight ‘Big-Tent’ Criteria for Excellent Qualitative Research.” *Qualitative Inquiry*, 16, no. 10 (2010): 837 – 851.

[25] Robert Donmoyer, “Generalizability and the Single-Case Study,” *Case Study Method: Key Issues, Key Texts,* ed. Roger Gomm, Martyn Hammersley, and Peter Foster (Thousand Oaks, CA: Sage Publications, 2000), 61 – 63.

Appendix C

QUESTIONS THAT GUIDED THIS RESEARCH

Political Climate

- What are the reasons given for building the nuclear power plant?
- What is the prevailing attitude toward nuclear power of the national government?
- If the government supports nuclear power, what are its reasons?
- What is the prevailing attitude toward nuclear power of the local government?
- If the local government supports nuclear power, what are its reasons?
- Do the political attitudes toward nuclear power affect the displacement of people?
    - How?
- List any specific policies directed toward the displacement of people, the compensation of those people, who handles the displaced, etc.
- Are the official policies the ones that are actually in place on the ground?
- Have those policies been shaped by the current attitude of the local toward nuclear power?
- Does the attitude toward nuclear power of the local people influence the response of those displaced or to be displaced?
- Do the local people share the views toward nuclear power held by the government/politicians?
- Is the government offering an subsidies, tax breaks, or other financial supports for the nuclear power plant?
- Are the financial supports offered actually received?
- Do those in power have any relationships with the nuclear power industry?
- Do any of the local or national politicians come from the area where the nuclear power plant is to be built?

Economics

- Who or what group or groups will own the nuclear power plant?
- Can the project be justified economically?
- What factors are included in the calculations?

- Do the costs cited/proposed for the construction and operation of the facility reflect the costs of relocating or compensating the people displaced by the use of nuclear power? If so, how?
    - If not, how might the costs of displacement be incorporated into cost estimates?
- What types of compensation were offered the original residents of the sites?
- Did they accept that compensation?
    - Why or why not?
- Did people who accepted compensation actually receive what was promised?
- What do the people really want?
- Will the local people have jobs in construction or operation of the plant?
- Will the local people benefit from the use of electricity generated by the nuclear power plant?
- Once the plant is in operation, will the local people be able to continue their current jobs/occupations?
- If they could not be involved in that occupation any longer, for whatever reason, what would they choose to do?

Safety and Risk

- How have safety and risk been conceptualized for the project in question?
- Were the local people told of any of the safety/risk issues related to having a nuclear power plant in the vicinity?
- Did or do safety and risk factor into the siting and displacement decisions made?
- How much weight was given to safety and risk relative to other factors in decision-making?
- Whose safety, if anyone's, was taken into account?
- What is the perception of the risk of living near a nuclear power plant on the part of the local people?
- What do the local people fear the most?
- Are those fears backed by scientific evidence?
- What is the perception of risk of a nuclear power plant as portrayed by the officials associated with the project?
- Were accidents at other sites considered when making decisions for this project?

Environment

- What environmental features characterized the site before it was chosen for the new nuclear power station?

- What plants and animals were found on the land?
- Was the land already developed? Were their other businesses on the land? If so what kind of businesses?
- Were there farms on the site? If so, what kinds of crops were grown? How large were the farms?
- How many people resided in the area now being considered for the nuclear power plant?
- Were there any environmental features that drew the nuclear power company to the site (proximity to water, for example)?
- What will be the impact of the plant on the local environment (excavation, building roads, bringing electricity to the site, pumping water to the site, use of construction vehicles, exhaust from the plant, water discharge from the plant, runoff, waste disposal, etc.)?
- How, if at all, has the landscape been altered by the planning for a new nuclear power plant?
- How, if at all, will the landscape be changed by the construction?
- Will a town or towns be constructed to house the workers during construction? Those who work at the plant?
- How will toxic, radioactive waste be disposed of?
- What pollution controls and monitoring programs are to be put in place?
- Has the impact on the environment been taken into account in the planning for the nuclear power plant?
- Have funds for the remediation of the site been allocated in the budget for the plant?
- How much money has been/will be set aside to address environmental concerns?
- Has the potential for environmental catastrophe and the need to evacuate people (as at Chernobyl or Fukushima) been taken into account in the planning for this project?

Displacement

- When did the local people first hear of the potential construction of the nuclear power plant in the area?
- How did they get the news?
- From whom (or what source of information) did they get the news?
- How did they respond initially?
- Has their opinion of the plant changed over time?
    - If so, why?
- What is their opinion now?

- What aspects of the planning, construction, and operation of the nuclear power plant will have the biggest impact on their lives?
- Were the local people consulted in the planning stages of the project?
- What groups of people were involved in the decision-making process?
- Do the local people feel that their concerns about the project were heard/understood/taken into consideration?
- Did anything change after the local people gave voice to their concerns?
- If the people are against the construction of a nuclear power plant, is it nuclear power itself that causes their concern, or would any large facility that would occupy a large swath of land and consume large quantities of water (perhaps a chemical plant) be problematic for them?

Appendix D

SCHEDULE OF JAITPUR TRIP VISITS

Day	**Date**	**Details**
Sunday	March 22, 2015	Train from Thane to Ratnagiri
		Meeting with Adv. Baba Parulekar, his office
Monday	March 23	Meeting with District Collector, his office
		Meeting with Police Officer at Sakhari Nate Police Station--Cancelled
Tuesday	March 24	Visits to Karel and Niveli Villages
Wednesday	March 25	Madban Village
		Evening meeting with Niveli villagers
Thursday	March 26	Morning: Tulsunde village
		Afternoon meeting with Adv. Shashikant Sutar in Rajapur City
		Evening meeting in Karel
Friday	March 27	Visit to Mithgavane
Sunday	March 29	Speaking with fishermen, workers at Nate port
		Visit to Jaitapur village
Monday	March 30	Group meeting with journalists in Ratnagiri
		Return by train to Mumbai
Tuesday	March 31	Meeting with people based in Mumbai affected by the Jaitapur Nuclear Power Plant
Wednesday	April 1, 2015	Meeting with Prof. Mahesh Kambel at Tata Insitute of Social Sciences

Appendix E

QUESTIONNAIRE QUESTIONS

Background Information

1. Are you Male or Female?
2. Age:
3. What is your current occupation/job?
    a. How long have you had that occupation/job?

The News

1. When did you first hear about the potential construction of the nuclear power plant in the area?
2. How did you get the news? (Newspaper, letter, from friends or family members, at a meeting, etc.)
3. How did you respond to the news?
4. Has your opinion of the nuclear power plant project changed over time? If so, why?
5. What is your opinion of the proposed plant now?

The Impact

1. What aspects of the planning, construction and operation of the nuclear power plant do you think will have the biggest impact on your life?
    a. Why?
2. Has the news affected life in your village?
    a. How?
3. Do you expect to lose your home, land, business, or job due to the construction of the facility?
    a. How did you receive that news?
    b. When?
    c. Was your home/land/business part of the family before you acquired it?
    d. Before the announcement of the construction of the NPP, had you expected to be able to pass your home/land/business on to family members?
    e. Will you be or have you been compensated?
    f. What is your opinion about that compensation?

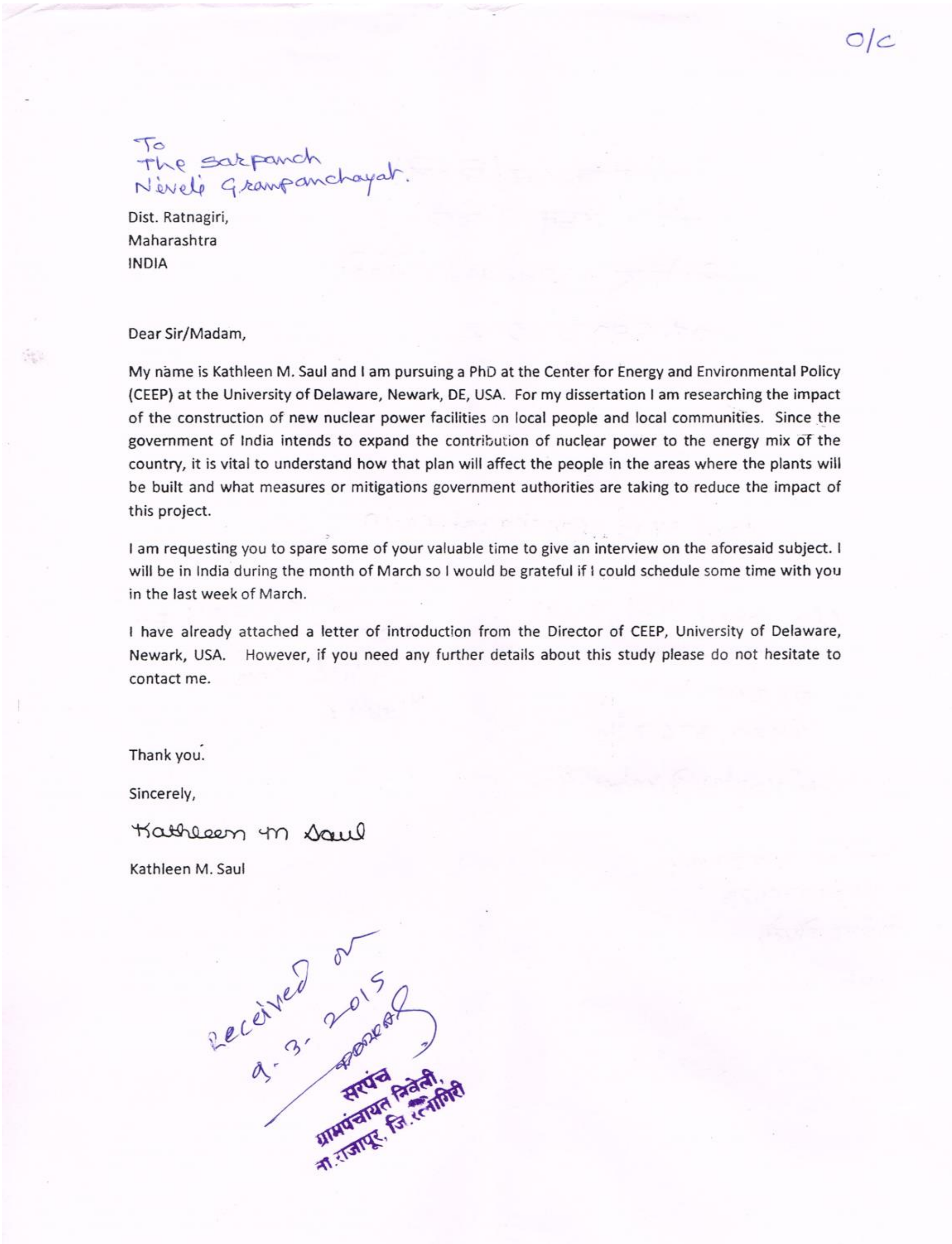
    g. Will you be/have you been given any assistance in finding a new home, land, job, etc.?
4. Have you or your family members been offered training for a new job or line of work?
    a. What is your opinion about the training or opportunities offered to you?
5. Have you or any of your family members been promised any job during the construction at the site?
    a. If so, what kind of job?
    b. Did you or a family member take it? Why or why not?
6. Will you stay in the area or move away once the construction gets under way? Why or why not?
7. What do you think about having outsiders in your community—those who will be brought in to build and operate the nuclear power plant?
8. Are there any other effects of the NPP that concern you?

The Future

1. What good do you think will come to the area from the planning/construction/operation of the nuclear power facility?
2. What harm might come to the area?

Appendix F

JAITAPUR LETTERS



O/c

To
The Sarpanch
Nivele Grampanchayat.

Dist. Ratnagiri,
Maharashtra
INDIA

Dear Sir/Madam,

My name is Kathleen M. Saul and I am pursuing a PhD at the Center for Energy and Environmental Policy (CEEP) at the University of Delaware, Newark, DE, USA. For my dissertation I am researching the impact of the construction of new nuclear power facilities on local people and local communities. Since the government of India intends to expand the contribution of nuclear power to the energy mix of the country, it is vital to understand how that plan will affect the people in the areas where the plants will be built and what measures or mitigations government authorities are taking to reduce the impact of this project.

I am requesting you to spare some of your valuable time to give an interview on the aforesaid subject. I will be in India during the month of March so I would be grateful if I could schedule some time with you in the last week of March.

I have already attached a letter of introduction from the Director of CEEP, University of Delaware, Newark, USA. However, if you need any further details about this study please do not hesitate to contact me.

Thank you.

Sincerely,

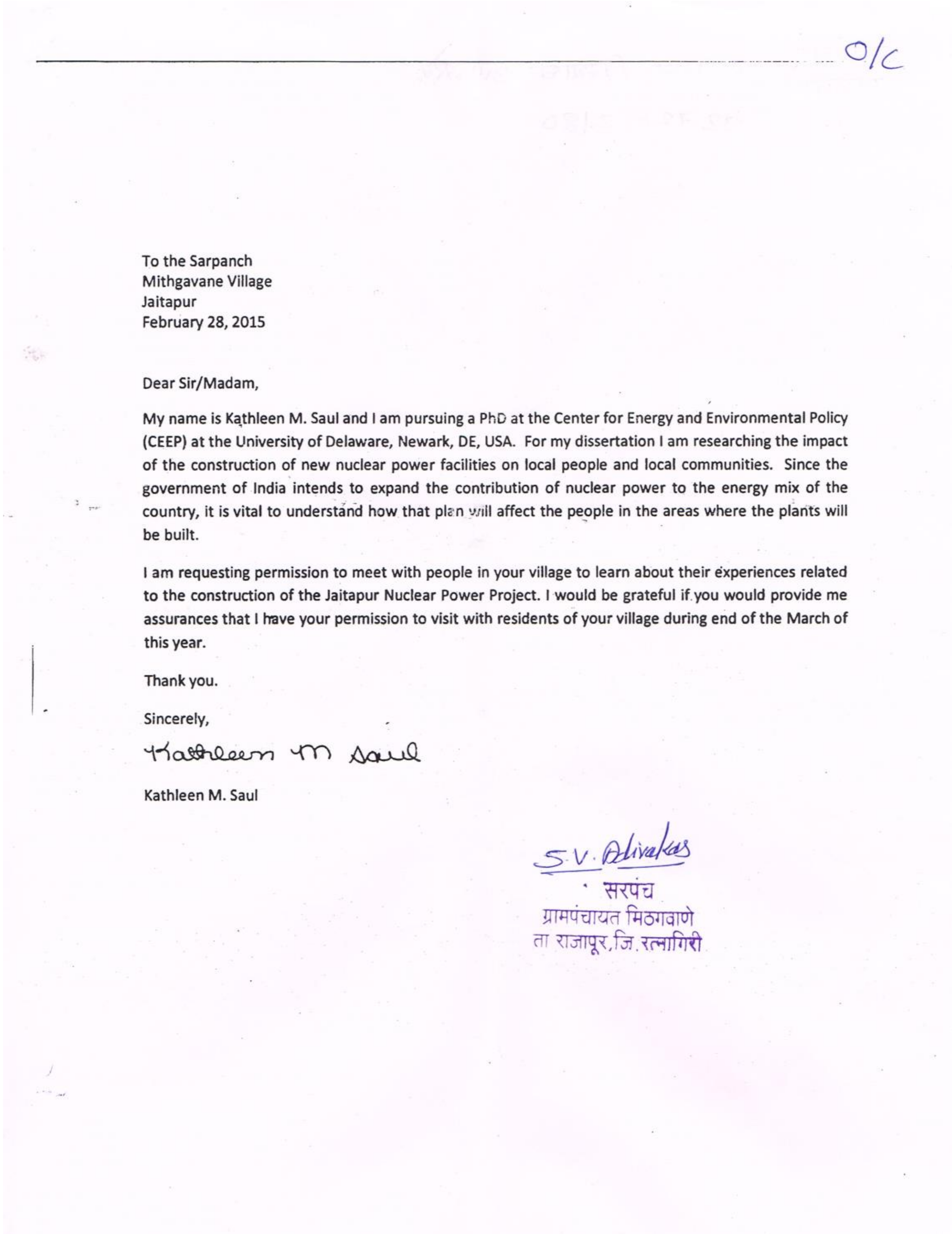
Kathleen M Saul

Kathleen M. Saul

Received on
9.3.2015

सरपंच
ग्रामपंचायत निवेली,
ता.राजापूर, जि.रत्नागिरी

Figure E.1 Sample Jaitapur Letter



O/C

To the Sarpanch
Mithgavane Village
Jaitapur
February 28, 2015

Dear Sir/Madam,

My name is Kathleen M. Saul and I am pursuing a PhD at the Center for Energy and Environmental Policy (CEEP) at the University of Delaware, Newark, DE, USA. For my dissertation I am researching the impact of the construction of new nuclear power facilities on local people and local communities. Since the government of India intends to expand the contribution of nuclear power to the energy mix of the country, it is vital to understand how that plan will affect the people in the areas where the plants will be built.

I am requesting permission to meet with people in your village to learn about their experiences related to the construction of the Jaitapur Nuclear Power Project. I would be grateful if you would provide me assurances that I have your permission to visit with residents of your village during end of the March of this year.

Thank you.

Sincerely,

Kathleen M Saul

Kathleen M. Saul

S.V. Adivalkar
सरपंच
ग्रामपंचायत मिठगवाणे
ता राजापूर, जि. रत्नागिरी

Figure E.2 Sample Jaitapur Letter