Acknowledgements

I owe sincere thanks to my advisor, Jeff Rider, for his guidance, patience, and countless words of wisdom.

Mom and Dad, thanks for encouraging me, for giving up your computer privileges, and for getting me hooked on France…and for your words of wisdom, too.
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I. The Seeds of a Nuclear State

The history of every community is a function of national and international interests, commitments, and circumstances. In the 1960s, a national experiment in French nuclear energy technology determined the fate of Brennilis, a 500-person town in the northwesternmost department of France, for almost a century. The decision to place a nuclear power plant in Brennilis seems irrational today, fifty years after the project began, as the town struggles to erase all trace of the plant. At the time of construction, though, this plan made sense, given a particular domestic and global context. A combination of risk-taking, poor planning, and external factors—regarding dismantling, in particular—transformed the Brennilis plant. Once regarded as showcase project and technological gem, it has recently come to symbolize the
negative implications of nuclear energy. Reflecting on the Brennilis case is helpful in evaluating the current protocol for planning and dismantling nuclear reactors.

Although France depends on nuclear power for approximately 80% of its energy production today—more than any other country—it began as an industry that was not smooth.\(^1\) Like the world’s other developed countries, France experienced an intense phase of technological enthusiasm at the end of World War II. World leaders were eager to prove the positive potential of nuclear power after the war had made the atom infamous for its destructive capacity. President Eisenhower, for example, launched an “Atoms for Peace” initiative in the United States in 1953 and established the Atomic Energy Commission (AEC) in the same year. In 1955, Geneva hosted an international conference on peaceful uses of the atom, which further motivated many countries to expand their nuclear energy projects.\(^2\)

In *Nuclear Politics*, sociologist James Jasper explains that the early research on nuclear energy reveals a “confidence that technology could solve political problems.”\(^3\) With this underlying optimism, various nations worked fast to improve infrastructures that would support their scientific goals. In France, this principle of technological enthusiasm led to the formation of two key organizations even before the 1953 creation of their American equivalents.

In 1945, General Charles de Gaulle established the Commissariat à l’Energie Atomique (CEA) as a public research organization to advance France’s agenda of


\(^{2}\) Ibid., 65.

accelerated development of nuclear energy in all its diverse applications. The creation of Electricité de France (EDF) was the second move crucial to France’s nuclear developments. This utility was born of a 1946 decision to nationalize France’s electricity industry.\(^4\) When CEA engineers designed the Commissariat’s first energy-producing reactors in the early fifties, EDF officials were eager to operate such plants. Although EDF and CEA have experienced some significant rifts since the beginning of their cooperation, efficient collaboration between the two firms has proven key to France’s success in the realm of nuclear energy.

As various countries developed their nuclear energy industries after World War II, different technologies appealed for different reasons. In his discussion of France’s early nuclear energy progress, Jasper insists on the notion that technologies are “shaped, constrained, or encouraged by their economic and political contexts.”\(^5\) Although scientists understood the basics of nuclear energy science when the CEA was created in 1945, important questions remained about the best ways to exploit nuclear energy. A basic understanding of nuclear reactors is thus important for making sense of the preferences of different countries concerning alternative nuclear technologies.

Fusion, a reaction in which neutrons combine—instead of splitting—and create extraordinary amounts of energy, appears to be the most efficient process to generate energy. Scientists, however, have not yet developed the science to mimic this type of reaction that occurs naturally—in the sun, most notably. The investment of

\(^4\) EDF was entirely state-owned at first, but France has since given up about 15% ownership of the utility. EDF currently operates 58 nuclear power plants in France.

\(^5\) Jasper, *Nuclear Politics*, 75.
enormous attention and resources in the development of this technology, though, makes it likely that humans will someday use this type of hugely productive reaction for energy purposes.

Fission, essentially the opposite reaction of fusion, is the type of nuclear process that humans reproduce in nuclear power facilities. After varying levels of enrichment, uranium is used as the principle fuel for nuclear reactions at power plants. In a reactor, tubes full of uranium pellets—fuel rods—are clumped together. Neutrons are then released to react with these pellets. When a neutron comes into contact with a uranium atom, the uranium atom’s nucleus splits into two lighter atoms, resulting in the release of a few neutrons, kinetic energy, gamma radiation, and heat.

To maintain conditions conducive to efficient fission reactions, certain controls in nuclear reactors are necessary. First, a moderator regulates the speed of the neutrons released to react with uranium, because neutrons traveling too fast tend to shoot through uranium atoms instead of reacting properly with them. To slow down the neutrons and thus better their chances of splitting the uranium atoms, a moderator acts as a retardant in the reactor. Fuel rods are submerged in a large tank of the moderator, most commonly water. A coolant, also usually water, is necessary to absorb some of the heat produced by the reaction. In many plants, water functions both as the moderator and as the coolant. Control rods also help to manage this fission reaction. These key features of the reactor help maintain the optimal number of neutrons by absorbing some when necessary. When control rods are needed, machines lower them into the reactor core and lift them out afterward. These rods can
be made of graphite or steel, as both materials can absorb neutrons. Although this basic process is consistent across nuclear technologies, different combinations of materials and input—such as fuel, coolant, and moderator—create distinct technological systems that appeal to different nations for different reasons.

In France, the choice of technology was based on national sentiments and technological ambiguity, although a global enthusiasm was also at work in the shaping of French policy. EDF initially avoided committing to one technology, given the scientific uncertainty surrounding the trade-offs associated with each option. The CEA, on the other hand, focused on developing a gas-graphite model; this type of plant runs on unenriched uranium with a gas coolant and graphite moderator. Gas-graphite technology appealed to French decision-makers both for its capacity to create plutonium for atomic weaponry and for its reliance on natural uranium, as opposed to enriched uranium that had to be imported from the United States or the Soviet Union. Moreover, the costs of this technology were projected to fall below those of foreign models, and national pride made the CEA’s option all the more attractive. A second reactor type, light water, later became the French standard, but was initially rejected because it required imported enriched uranium and seemed less economical than other technologies in the long term.

A third alternative, championed by Sweden, was heavy water technology, which called for natural uranium and heavy water—water with deuterium atoms in place of hydrogen atoms. This unique atomic composition creates a more effective moderator and thus a more efficient fission reaction. Britain and Sweden were among

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6 Jasper, *Nuclear Politics*, 75.
the European countries developing heavy water technology in the 1960s, and France was intrigued by this model that seemed like it might be less expensive and less reliant on imports than alternatives. In an effort to diversify its energy production methods, and because it lacked entirely decisive data on the relative merits of various technologies, the CEA hedged its bets by pursuing heavy water technology in addition to gas-graphite and light water models. In 1957, the CEA decided to construct an experimental heavy water reactor, and in 1962 it chose Brennilis as the site for this prototype.⁷

⁷ Ibid., 75.
II. The Brennilis Plant in Context

The town of Brennilis sits near the middle of the northwesternmost department in France, Finistère. Brennilis is one of eight communities that make up Yeun Elez, a “communauté de communes” whose land is characterized by marshes, peat bogs, rich grasslands, and the rocky hills of the Monts d’Arrée range. This natural boundary once served as the divider of Cornouaille and Léon; the southern portion of the Brittany peninsula settled in the Middle Ages by princes from the region of Cornwall made up Cornouaille, and Léon was established in the Middle
Ages as a bishopric under the sovereignty of the Duke of Brittany in the northern part of the peninsula. The eight towns collaborate—through meetings to which each community sends delegates—to promote progress in the interest both of individual towns and of the Yeun Elez region as a whole.\(^8\)

The heavy water nuclear power plant was constructed in a period of remarkable social and quality of life changes in Brennilis. In *Ethnicity, Folklore, and Local Identity in Rural Brittany*, anthropologist Ellen Badone explains that “social change in this region has moved at a rapid pace since the mid-1950s, and those who have lived through the intervening period have participated in two strikingly different worlds.”\(^9\) In the late 1950s, when Brennilis was pegged as an ideal site for the experimental reactor, the town had only known electricity for about a decade, and Brennilis residents still spoke mostly Breton.\(^10\) Before being dominated by the nuclear energy industry, Brennilis’s economy centered on meat preparation. A meat processing business, les Salaisons d’Arrée, employed the majority of the workforce. The pilhaouerien lifestyle, in which men roamed to recover and recycle used textiles, characterized rural Breton society pre-1950 but disappeared gradually in the mid-twentieth century.\(^11\)


If this region was renowned before the nuclear plant’s construction, it was for its mythological associations. According to Breton folklore, the Monts d’Arrée were home to Ankou, the king of the dead. Traditionally recognized as the Gates of Hell, the Yeun Elez region was an ironic choice for host of a potentially dangerous nuclear power plant. The title of the region’s department, Finistère, evolved from the Latin “finis terrae,” meaning “ends of the Earth,” and this entire region retains a certain mystique that has piqued the curiosity of outsiders and artists. The irony of the power plant placement and the unique aura of the region inspired cartoonist Jean-Claude Fournier, for example, to craft a comic book in 1978 about his famed Spirou and Fantasio duo meeting Ankou and learning about the power plant that existed in this creature’s dark, evil world.

The Yeun Elez landscape stands out for other reasons, though, than its folkloric associations. The Parc Naturel Régional d’Armorique was established in this region in 1969 to protect the land’s biodiversity. The park includes over 172,000 hectares of Finistère’s marine and terrestrial environment. Since the creation of this park, the region’s natural splendor has made it an increasingly popular “green tourism” destination for travelers. The potential for development of this type of industry became especially important when the Brennilis plant stopped operating in 1985; residents and politicians desperately sought alternatives to revive and sustain the local economy.

The larger region of Brittany is notable for its unique relationship with the rest of France, and a familiarity with this dynamic is key to a thorough understanding of the Brennilis nuclear plant’s history. After Celtic soldiers from Britain conquered this
Roman-occupied land—called Armorica—in the late fourth century, the region was split into Domnonia, Cornouailles, and Bro Waroc’h; this division existed until the region was unified in the ninth century, resulting in the Duchy of Brittany. With help from Danish Viking soldiers throughout the eighth and ninth centuries, Bretons were able to fight the Franks, who were trying to add Brittany to their territory.

A series of strong dukes and periodic victories against the French preserved Brittany’s independence until its incorporation into the Kingdom of France in 1532. Although Brittany maintained some autonomy after this unification, it inevitably became involved in France’s national projects, such as its commercial and colonial endeavors. In 1789, Brittany lost all remaining independence with the abolition of feudal privileges across France and was split into five departments, consistent with the organization of the rest of the nation.

Brittany became a center of resistance to the French Revolutionary government after 1789, and after the Revolution’s end in 1799, the region remained characterized primarily by traditionalism and an agriculture-based economy—and by a commitment to preserving its unique way of life. Separatist sentiments had existed since the incorporation of Brittany into France in 1532, but they burgeoned in the late 1800s and early 1900s. During the peak of the movement, separatism aligned largely with leftist schools of thought and developed into various political factions and militant groups. Although an alliance with the Nazis dealt a significant blow to the separatist movement’s image during World War II, the faction has maintained its presence through violent and non-violent activities. Separatists would later be implicated in attacks on the Brennilis nuclear plant.
Fig. 3 A demonstration outside the Brennilis power plant after its decommissioning, from Brennilis: la centrale qui ne voulait pas s'éteindre (Vivement Lundi, 2008).

III. From Popular to Obsolete

Several factors contributed to the decision to construct a heavy water plant in the Monts d'Arrée region. First, a stable geologic plate beneath the site posed no threat of dangerous seismic activity. The granite present in the Monts d’Arrée region was also desirable for its ability to support extremely heavy structures. An accessible water source was another primary concern, given the reliance of heavy water nuclear technology on a constant, large water supply. The Brennilis site is less than a kilometer from the Reservoir de St. Michel, a man-made lake created in 1935.

in the Yeun Elez marsh area.\textsuperscript{13} The availability of vast property with no particular agriculture value and no large town made the Brennilis site an appealing candidate, as did the presence of a sizable potential workforce nearby. Moreover, the draw for tourists was minimal.

When Brennilis was chosen in the late 1950s as the site of this experimental reactor, community members seemed generally hopeful about the plant’s impacts on their community, despite fervent anti-nuclear sentiment in other parts of France. Because the plant’s energy production capacity would be small—70 MW—the major appeal of the nuclear plant to the town was the financial benefit it promised.\textsuperscript{14} EDF acknowledged the need for a financial carrot to make nuclear power plants attractive to municipalities and implemented incentive structures for this reason. The “patente,” the license money paid annually by the power station to its host community, was the crux of the economic incentive for Brennilis, a town whose aging infrastructure stood to benefit greatly from increased funds.

Brennilis residents also liked the fact that the construction of a nuclear reactor in Brennilis meant new employment opportunities. The plant created jobs for current residents and for an influx of workers—some for long-term positions and some for temporary posts, when maintenance or inspection brought outsiders to the Brennilis site. In Brigitte Chevet’s documentary about the Brennilis plant, a former worker describes the reasons some French were eager to work at the plant. “J’ai retrouvé d’autres copains [à Brennilis] who were coming from other plants…who were excited to be able to come back to the region and work on something that was on the

\textsuperscript{13} Ibid.
cutting edge, that was novel.”\textsuperscript{15} The motivation described in this recollection reflects a combination of enthusiasm about job opportunities and the distinct technological enthusiasm that pervaded France in the decades immediately after World War II.

A segment of television news that aired in April 1966 reveals similar optimism among Brennilis residents at the beginning of the plant’s construction. When the journalist solicited opinions on the plant, one resident replied that “everyone was happy when they announced…that they were going to build a plant in Brennilis. The region was poor, young people were leaving. And now they found jobs.” Other interviewees agreed with the notion that “it does a lot of good for the area, for the labor market, because we really needed it.”\textsuperscript{16}

Construction on the Brennilis plant lasted from 1962 to 1966. In these years, Brennilis faced the enormous challenge of accommodating the influx of hundreds of workers involved in the mammoth building project. Harsh winter weather—especially in 1963—and a serious housing shortage made the construction process especially difficult for the workers. CEA and EDF funded construction of housing for workers in Brennilis and in surrounding towns.\textsuperscript{17} Managers, though, generally lived outside the Monts d’Arrée area, in the nearby town of Morlaix.\textsuperscript{18} Many workers who were recruited from outside Brennilis, most notably a large Portuguese contingent, remained in Brennilis even after completing the construction.\textsuperscript{19}

\textsuperscript{15} Brennilis, la centrale qui ne voulait pas s'éteindre. Dir. Brigitte Chevet. Vivement Lundi, 2008. DVD, 9:04.
\textsuperscript{16} Ibid.
\textsuperscript{17} Chartier, "Retour à l'herbe à Brennilis," 37.
\textsuperscript{18} Ibid., 37.
\textsuperscript{19} Ibid., 37.
The construction work was rigorous, but a certain spirit of unity among workers allowed for a pleasant atmosphere at the site. Former worker Yves Corre recalls a solidarity among the builders, who worked in a “beehive” of activity, as he remembers. One Brennilis resident, Christian Blanchard, described the transformed town as “le Far West,” alluding to the many caravans brought into the town to house workers.\(^{20}\) He remembers that “in a short period, what had been a small, calm village tripled or quadrupled in population.”\(^{21}\) At some points there were more than a thousand workers. Overwhelmed with customers, some restaurant owners converted their venues into cinemas at night, and old farm buildings were converted “into nightclubs.”\(^{22}\) On July 9, 1967, the reactor was connected to the electricity grid and thus began its functional life.

The anticipated financial benefits proved real after the plant's construction. The patente paid to Brennilis helped to finance a football stadium, renovations to local government offices, and facilities for the elderly.\(^{23}\) A water tower, water distribution infrastructure, and new campgrounds were also products of this new source of funds.\(^{24}\) In 1979, the Giscard government went even farther to make nuclear power plants attractive. This administration implemented a ten percent discount in electricity fees for residents living within a ten-kilometer radius of nuclear plants.

Although the nature of the town’s response to the Brennilis plant had some

\(^{20}\) Ibid., 37.
\(^{21}\) Ibid., 37.
\(^{22}\) Ibid., 37.
\(^{23}\) Mounfield, *World Nuclear Power*, 105. The closest estimate I could find of the patente amount was in Mounfield’s text. He reports that the yearly patente was 50,000 British Pounds. In 1991, that equaled roughly $90,000 U.S. dollars.
implications for the operation of the plant, changes to the broader national and international contexts of the nuclear industry essentially determined the fate of the Brennilis plant. The community’s embracing the plant seemed to bode well for the plant’s future, but global shifts would render this local reaction relatively unimportant in shaping the plant’s future.

The international oil crisis of 1973 was ultimately the impetus for change; it challenged the stability of the traditional fossil fuel-based energy paradigm. This crisis had a profound impact on energy policy worldwide and had especially important implications for the development of nuclear power in France. Although EDF had long been enthusiastic about nuclear energy, it was not until after the 1973 embargo that France could seriously “unleash EDF’s nuclear ambitions.”

The French Government’s Messmer Plan of 1974 made this shift toward nuclear power official. The Messmer Plan—named for the French Prime Minister at the time—laid out a program that included construction of thirteen new nuclear plants in 1974 and 1975 as an answer to the oil crisis. These new plants were slated to produce about twice the amount of energy EDF had the capacity to produce at the time the Plan was written. The Messmer Plan appealed to technological enthusiasts and those preoccupied with energy independence, but it enraged those French citizens who saw it as “a symbol of Pompidou’s subservience to international capital.” In any event, this comprehensive outline for the accelerated construction of a nuclear power-based state sparked critical discussion of this new energy type.

26 Ibid., 156.
27 Ibid., 160.
One consequence of this increased salience of energy policy after the oil crisis was the strengthening of the anti-nuclear movement worldwide, a threatening phenomenon to nuclear plants everywhere. Just before the crisis, from 1969-1971, French environmental groups began to build coalitions and expand their network of resources and energy after years of disjointed and largely ineffective action. The most rapid expansion of anti-nuclear activity in France occurred in 1971, and the oil crisis a couple years later reinforced for anti-nuclear activists the urgency of their message, necessitating debate about and reflection on national energy policy. The oil crisis cemented nuclear energy’s role as a unifying issue for environmental groups. With the assumption that this burgeoning anti-nuclear movement would weaken with the provision of more public information, the French government saw little reason to worry about the potential actions of those who opposed its Messmer Plan and its decision to prioritize nuclear over all other power sources.\textsuperscript{28} The anti-nuclear front, however, did not deteriorate in the several years following the oil crisis.

On the contrary, the anti-nuclear movement grew until it reached a peak in 1980 with major demonstrations against the construction of a reactor in Plogoff, a Finistère town under 50 miles from Brennilis. Whereas the opposition was strong in this nearby town, the prospect of a Brennilis plant had incited no such outrage among locals a couple decades earlier. During the majority of the time the Brennilis plant was in operation, the anti-nuclear movement relied largely on site-specific activist groups scattered throughout France. Given all the financial benefits the Brennilis plant promised the community, it is no surprise that anti-nuclear sentiments did not

\textsuperscript{28} Ibid., 148.
drown out technological enthusiasm in Brennilis as they did in some other French reactor towns. It was, instead, the dismantling process and an improved understanding of nuclear science that provoked the most serious debate in the Brennilis plant’s history.

In her documentary on Brennilis, Brigitte Chevet claims that the lack of local opposition might also have been due to poor communication and misleading messages by EDF and CEA to Brennilis residents and plant workers. Although the financial advantages of the plant’s operation were obvious to members of the community, the risks were much less evident. In any event, a lack of fervent anti-nuclear activity in Brennilis kept strong opposition—a side effect of the 1973 oil crisis in some towns—from threatening the Brennilis plant’s future.

It was a different—and perhaps more indirect—result of the oil crisis that led to the reactor’s demise. This crisis was especially important in Brennilis because it placed efficiency at the center of conversations about nuclear policy, leading to a technological shift throughout France. Because the Messmer Plan called for maximum mobilization of France’s heavy industry, the French government needed to be sure to use the most efficient technology available. This pressure led to a nationwide technology switch from the French-developed heavy water technology—debuted in Brennilis—to an American line of light water pressurized reactors, which officials believed would optimize the industry’s productivity.29

France’s delay in adopting the light water technology was due to a traditional Francocentric perspective of progress. Sociologist Jasper points out that until the

29 Ibid., 154.
1969 election of George Pompidou, “the political elite clung to a view of national interest as autonomous technological development rather than as the ability to compete on international markets.”\(^\text{30}\) When dissent between the centralized regulator, CEA, and the centralized power producer, EDF, left the choice of reactor technology to Pompidou, though, American technology prevailed. This light water technology seemed more likely than the existing French system to become cost-effective in the short term, even though its costs turned out, ultimately, to increase more than expected in this initial development stage.\(^\text{31}\) Only a few years after the Brennilis plant began producing energy, its heavy water technology was outdated.

The Brennilis facility’s experimental technology faded as a subject of public and media interest, but two events put the Brennilis plant back on the radar of the French nuclear community. Two incidents of terrorism—one in 1975 and one in 1979—targeted the Brennilis plant. These acts claimed no human lives and were ultimately probably not anti-nuclear in purpose, but they are nonetheless important for the way they reflect the dynamic between Brittany and rest of France. On August 15, 1975, the explosion of two bombs caused only "minor damage" to the filtration plant and chimney stack.\(^\text{32}\) On January 14, 1979, bombs damaged power lines to the plant, disrupting its operation.\(^\text{33}\) The Front de Liberation de la Bretagne (FLB) and the Armée Révolutionnaire de Bretonne (ARB), notorious Breton separatist groups, were

\(^{30}\) Ibid., 100.
\(^{31}\) Ibid., 101.
suspected but never tried for these crimes.\textsuperscript{34}

Although reporter Erwan Chartier describes these attacks as “a manifestation—let’s call it a noisy one—of the Bretons’ refusal of nuclear power,” other historians see the terrorism as part of a broader social movement.\textsuperscript{35} In his book \textit{Nuclear Terrorism: a Threat Assessment for the 21st Century}, Gavin Cameron explains that "a campaign against nuclear power, came to be subsumed into a wider revolutionary struggle in France."\textsuperscript{36} He draws a parallel to the case of Euskadi Ta Askatasuna (ETA), a Basque nationalist organization responsible for attacks on nuclear plants and their workers in Spain. Cameron articulates that "the driving force behind the increasingly broad-based anti-nuclear movement had become anger at the highhandedness of the Spanish government and Iberduero SA (the electricity company), and the lack of democratic procedures in arriving at the decisions [to build nuclear plants]."\textsuperscript{37} The attacks on the Brennilis plant appear similarly tied to a broader movement, the separatism that has long characterized Brittany.

\textsuperscript{35} Chartier, "Retour à l'herbe à Brennilis," 39.
\textsuperscript{36} Cameron, \textit{Nuclear Terrorism}, 121.
\textsuperscript{37} Cameron, \textit{Nuclear Terrorism}, 121.
Fig. 3 An excerpt from the comic book L’Ankou, by Jean-Claude Fournier, inspired by the Brennilis plant, from “BRENNILIS : Le démantèlement des centrales nucléaires françaises est mal parti.” (Borvon, 2009).

IV. A Complicated Cleanup

Six years after this second attack, on August 9, 1985, le Service Central de Sûreté des Installations Nucléaires authorized the closure—the Mise à l'Arrêt Définitif (MAD) of the Brennilis plant. The CEA and EDF had announced the closure in May 1984, citing structural deterioration, related inefficiency, and outdated technology as the principle factors in this decision.

Nuclear energy facilities close for various reasons. Safety considerations might lead to decommissioning, as could policy change that renders a facility unlawful. A facility might cease to be cost-effective or become too technologically

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out-of-date.\textsuperscript{39} Other motivations for shutdown include accidents and the conclusion of a research project or experimental program.\textsuperscript{40} The International Atomic Energy Agency (IAEA), which dictates decommissioning protocol for plants worldwide, states that the goal of decommissioning is to “protect human health and the environment from the radiological & non-radiological hazards resulting from the shut-down facility.”\textsuperscript{41} The IAEA also recommends that decommissioning be planned during the plant’s design phase, rather than after the facility has finished operating, and that cost-benefit analysis should determine optimal decommissioning strategies.\textsuperscript{42}

The Brennilis plant’s dismantling method is consistent with the three-phase procedure that the IAEA recommended at the time of the plant’s decommissioning. According to IAEA protocol, “storage with surveillance” defines Stage 1; this initial phase consists of completion of all shutdown-related operations and evacuation of used fuel from the plant site. Stage 2 consists of “restricted site release,” during which equipment in all structures but the reactor building is disassembled and removed.\textsuperscript{43}

After the walls of the empty rooms are cleaned, the buildings are destroyed. Throughout Stage 2, the old electrical system and heavy water systems contaminated with tritium are the only parts of the reactor building that are dismantled.\textsuperscript{44}

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\textsuperscript{39} Ibid., 3.
\textsuperscript{40} Ibid., 3.
\textsuperscript{41} Ibid., 3.
\textsuperscript{42} Ibid., 7.
\textsuperscript{44} Ibid.
\end{flushleft}
intermediate phase, new alarm and security systems are installed, among other changes that leave the reactor structure intact. The timeline of Stage 3, ending in “unrestricted site use,” is tailored to each site. During this last phase, a period of inactivity may be used to weaken the core’s radioactivity—taking advantage of radioactive elements’ natural decay—enough to render the site suitable for other types of usage.

At the Brennilis plant, the dismantling process has proven to be “avant tout [une] affaire de patience.”

Retour à l’herbe – or “return to grass” – represents the ultimate goal of the dismantling process: completely deconstructing the plant in order to transform the site back into usable green space. Stage 1 began immediately after the plant stopped producing energy in 1985. Fuel cartridges were removed and taken to the Cadarache nuclear facility in southeastern France for storage along with the contents of the heavy water circuits, after the tritium had been removed at l’Institut Laue-Langevin in Grenoble. The cooling pools were also drained. When all of these elements of Stage 1 were complete in 1992, already 99% of the plant’s radioactivity had been eliminated.

Stage 2 did not begin immediately after Stage 1. At a point between these two stages, pressure from advocates led to a mandate calling for public inquiry, and on December 1, 1995, “l’Observatoire du Démantèlement” was created as one such framework for debate and information sharing. At meetings of the Observatoire, local and regional politicians came together with plant workers, representatives of EDF,

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environmental organizations, and Brennilis residents to discuss the progress and the future of the dismantling. Although this group had no mandate to make decisions, it was established to foster communication among the different stakeholders, and it fulfilled EDF’s vow to maintain candidness throughout the dismantling process. Although the Observatoire was largely a symbolic entity at first, it played a more essential role later, dealing with contentious issues concerning Stage 3.

Stage 2 lasted from September 1997 to mid-2007. In this period, equipment removal allowed all 346 rooms to earn non-radioactive status. Certain circuits in the reactor building were dismantled, but the rest of this main building’s infrastructure remained intact. Security and containment features were improved. In addition, solid waste and irradiated fuel storage rooms, as well as the station that treated liquid wastes, were decontaminated and dismantled.

The transition between the second and third stages was not as smooth as the shift from the first to the second. EDF originally wanted to wait between forty and fifty years to begin dismantling the reactor building, the only remaining structure on the site. In 1996, an ordinance articulated EDF’s plan to conserve the remaining buildings on the site under strict surveillance for this lengthy period of time. This ordinance also requested, though, that the CEA submit to the ministers of environment and of industry a study comparing alternative plans for a faster-paced dismantling; at the end of 1999, the CEA completed this study and submitted it for  

47 Foire aux questions, 8.  
49 Davis, "Brennilis."
This analysis turned out to favor a quicker dismantling, leading the CEA and EDF to propose 2018 as the end of the dismantling process. The decade that followed has been characterized by ongoing debate over this dismantling timeline.

The conflict between immediate and deferred dismantling is not unique to Brennilis and can revolve around a host of concerns. When decommissioning costs are known and funding is available, firms might opt for immediate dismantling. Firms are also likely to avoid delay when immediate dismantling is projected to be cheaper than deferred dismantling, or when future costs are uncertain. The availability of waste disposal sites, technological capacity, and personnel are other factors. From a regulatory standpoint, uncertainty about future policy might encourage a plant to begin dismantling immediately. Public opinion might become increasingly favorable with a faster dismantling strategy in light of the idea that quicker deconstruction means that the site will be available sooner for alternate use. Finally, acting quickly to dismantle means that a plant’s liability expires sooner and that its license—which can be costly—may be terminated earlier.

In other cases, however, it is logical to wait to dismantle a decommissioned plant. Funding gaps might force stalling. A voluntary deferral might occur if firms want to give radioactive elements a chance to fade naturally according to their half-lives. After waiting a few decades, dismantling personnel will be exposed to the radioactive material after its radioactivity has decreased exponentially; dismantling immediately after decommissioning would expose workers to dangerous material that

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50 Ibid.
51 Chartier, "Retour à l'herbe à Brennilis," 41.
has had no such chance to decay. Furthermore, if there are any issues with waste management, deferring dismantling offers firms some time to resolve them.\textsuperscript{53}

Anticipation of technological development is another reason firms opt to delay dismantling. Scientific progress develops at an unpredictable pace; researchers could at any moment be on the brink of a significant discovery that would mean a safer or more efficient dismantling process. Waiting better\textsuperscript{s} the chances that a plant will reap the benefits of a potential breakthrough in the near future. Deferring dismantling also might help a firm profit from an industry-wide learning curve, if a certain technology is relatively recent. Although a quicker dismantling appeals because it makes the site available for more immediate use, deferred dismantling can leave parts of the site ready for such immediate reuse.

At Brennilis, aside from anticipation of scientific development and cost concerns, some additional issues factored into the debate. One potential downside to deferring dismantling at Brennilis was that adequate surveillance over such a long period of time in such a remote location seemed unlikely.\textsuperscript{54} Concerns also surfaced about the prospect of the degradation of the concrete and metal infrastructure and the resulting exposure of radioactive material. Questions over the future financial climate of Brennilis also made deferred dismantling less appealing to some residents.\textsuperscript{55} Members of les Amis de la Terre, a French environmental group, also worried about the collective memory that would be lost in the decades before dismantling began. They feared that “forty years from now, when everyone wants to dismantle the

\textsuperscript{53} Ibid., 9.
\textsuperscript{55} Chartier, "Retour à l'herbe à Brennilis," 41.
waterproof outer wall and its interior, we will have forgotten the particularities.”

Another motivation to avoid delay was the hope that Brennilis might serve as an example for other similar sites; a quicker return to nature would mean a more appealing model for other cities. Jean-Yves Cozan recalls explaining to Jacques Chirac in 1995 that “if France wanted to continue to sell nuclear plants to other parts of the world, particularly in China, it would have to be able to assure service after the plant stops operating and be able to clean up the site.”

Several important voices echoed these beliefs and influenced the decision to switch to an immediate dismantling scheme. André-Claude Lacoste, head of the Direction de la Sûreté des Installations Nucléaires (DSIN), the French nuclear safety authority, pushed for an immediate dismantling effort. He believed the best plan was to “demolish everything and return the site to its natural state.” Michel Noraz, who was in charge of the plant, also supported immediate dismantling so that the plant would be “exemplary.” He foresaw an opportunity to “allow stakeholders to export their experience abroad” if Brennilis’s dismantling was quick to appeal to other countries. Whereas EDF was more concerned about the economic bottom line, the CEA viewed accelerated dismantling as an important technological challenge and

56 Ibid., 41.
57 Martine, "Sous le regard vigilant des élus Bretons."
58 Chartier, "Retour à l'herbe à Brennilis," 41.
59 The DSIN has since been renamed twice; it was dubbed the Direction Générale de la Sûreté Nucléaire et de la Radioprotection (DGSNR) in 2002 and L'Autorité de sûreté nucléaire (ASN) in 2006.
61 Ibid.
62 Ibid.
was thus motivated to attempt it.\textsuperscript{63}

The Parc Naturel Régional d'Armorique was another important force in the decision-making process regarding pace of dismantling. Its president, Jean-Yves Cozan, did not trust the decision of the CEA and EDF to delay dismantling. Cozan introduced the slogan “retour à l’herbe” and launched a lobbying campaign to make EDF, the CEA, and the entire community think more critically about the choice to delay dismantling. Cozan and his supporters placed hundreds of signs and stickers throughout Brennilis. Residents rallied behind Cozan as his cautionary message resonated more and more. An Armorica worker, Jean-Yves Kermarec, articulated the imperative of obtaining a technical analysis independent of EDF and the CEA to prove the merits of more immediate action.\textsuperscript{64} By soliciting help from les Amis de la Terre and an independent research organization, the “retour à l’herbe” campaign succeeded in “putting a little pressure on, and scaring CEA and EDF.”\textsuperscript{65}

In light of these opinions, EDF decided in 2001 to opt for immediate dismantling of its nine shut-down power plants, including the Brennilis plant, and a 2006 decree implemented this fast-paced dismantling program.\textsuperscript{66} This decision incited a quick response, however, from Brennilis residents and anti-nuclear activists wary of EDF’s judgment. The Observatoire had provided an entry point into the debate for Sortir du Nucléaire Cornouaille (SDNC), an anti-nuclear group focusing on issues in the Cornouaille region, the southernwesternmost portion of Brittany. This organization is one of over 800 groups that make up the Reseau Sortir du Nucléaire,

\textsuperscript{63} Chartier, "Retour à l'herbe à Brennilis," 41.
\textsuperscript{64} Ibid., 40.
\textsuperscript{65} Ibid., 41.
\textsuperscript{66} Foire aux questions, 11.
an umbrella organization for anti-nuclear groups in France. The Cornouaille branch has focused much of its attention on the Brennilis saga beginning in January 2005, when it was permitted to participate in the Observatoire. It was representatives of SDNC who requested in an April 2006 meeting of the Observatoire that the decree for immediate dismantling be annulled.

Later that month, SDNC received results of a test it had commissioned from an independent radioactivity research organization, the Commission de Recherche et d’Informations Indépendantes sur la Radioactivité (CRIIRAD), to conduct. The study aimed to measure radioactivity levels in sediment and plants just outside the plant site, in a channel which treated effluent from the plant and that reaches the nearby Ellez River. Results showed evidence of abnormally high levels of contamination—most clearly by the radioactive isotopes Cesium 137 and Actinium 227. The conclusion that further testing should precede dismantling supported SDNC’s request that the immediate dismantling decree be called off.

In 2007, the Conseil d’Etat cancelled the decree on the grounds that the public had not been properly informed about the plan or involved in the decision-making process. This sequence was viewed as a serious victory for Brennilis residents and for anti-nuclear groups concerned about the lack of information provided about the relative risks, costs, and trade-offs of an immediate dismantling track. For the first time, anti-nuclear voices had managed to change the fate of the Brennilis plant.

In this context of public insistence on information and communication, the

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Observatoire dissolved in December 2008 with the creation of the Commission Locale d'Information (CLI). The CLI shared the Observatoire’s initial goal of ensuring transparency throughout deliberations on the Brennilis plant’s future. Since the CLI’s creation, President of the Finistère General Assembly Pierre Maille has directed the Commission, which is composed of twenty-two elected officials, seven representatives of regional environmental organizations, five workers' representatives, and nine representatives of other stakeholder groups. In its first year of existence, the CLI played a key role in informing community members of developments in the dismantling debate. The CLI is required to meet at least twice a year; it convened five times in 2009.

The creation of the CLI was the culmination of a long struggle for institutionalized transparency in the Brennilis dismantling saga. One source of pressure on EDF to work toward greater transparency regarding the Brennilis project was a poor inspection report by l'Autorité de Sureté Nucléaire (ASN). The ASN is an independent entity that oversees the safety of radioactive environments in France on behalf of the workers, nearby residents, and natural surroundings. The ASN, which conducts inspections of nuclear facilities, has the authority to suspend plant operation and the responsibility of assisting the French government in case of emergency. With a priority on public information, the ASN inspects the Brennilis plant at least twice a year and posts its notes online. When ASN inspections in May 2006 revealed corrosion on barrels of waste and inconsistencies in the plant's bookkeeping—most notably, a significant underestimation of the radioactive waste in storage on site—

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Brennilis community members put pressure on officials to be more meticulous in their oversight and to communicate clearly with the public throughout the dismantling process.  

The 2007 decree that annulled the authorization of the immediate dismantling process reinforced this demand for greater transparency; it included an article that called for a period of public inquiry. Two elements, “l'enquête publique” and consultation, ended up at the center of the discussions of dismantling. According to the Commission Nationale du Débat Publique (CNDP), a public inquiry is defined as “a procedure open to everyone, without any restriction, that allows the public to be informed and to express their opinions, suggestions, and alternative propositions.” Consultation refers officially to “the process by which the deciders ask the opinion of a third party in order to be familiar with its views, expectations, and needs...The third party, however, has no certainty that its remarks or contributions will be considered in the final decision.”

To ensure a thoroughly informed opinion, the CLI decided to consult an external organization with experience in issues of nuclear energy. The committee chose the Association pour le Contrôle de la Radioactivité dans l'Ouest (ACRO), for additional guidance. Created in 1986, ACRO is a non-governmental organization that operates a radioactivity analysis laboratory. ACRO was formed to provide a

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71 Ibid., 64.
source of independent testing for communities seeking reliable information regarding local radioactivity levels.

Like at all nuclear facilities, the treatment of radioactive waste at Brennilis has always been a primary concern. Four principles guide EDF’s approach to waste treatment throughout plant operation and dismantling: limiting the amount produced, sorting by the nature and level of radioactivity, packaging and preparing the waste for long-term management, and isolating the waste from humans and the environment.\(^72\) EDF insists that radioactive waste has no contact with the water or soil in the area around the complex. When the radioactive material leaves the plant’s buildings, it is packaged in airtight containers, according to EDF, that leave no risk of environmental contamination.

Waste from Brennilis can be separated into two categories: short-lived waste and long-lived waste. Brennilis waste with a relatively short half-life has been sent to specialized centers in northeastern France operated by the Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA).\(^73\) Waste with a longer half-life has been sent to a treatment facility in northern France run by Areva, a mammoth French state-owned nuclear company.\(^74\) After four to five years of use in a nuclear reactor, 96% of the uranium can be recycled, and the remaining 4% is discarded using complex technology involving intensive packaging and isolation.\(^75\)

The dismantling of the site includes a careful treatment of all parts of the reactor complex with regard to their potential to host radioactivity. Each part of the

\(^{72}\) *Installations Nucléaires de Brennilis: Rapport Annuel*, 34.  
\(^{73}\) Ibid., 35.  
\(^{74}\) Ibid., 36.  
\(^{75}\) Ibid., 36.
site is analyzed and then characterized by the likelihood of detecting radioactivity there. Next, the proper means of treatment is identified, as is the best way of controlling and measuring radioactivity in the future. EDF employees ensure that residual pollution and related radioactivity will not threaten the quality of the groundwater in the area.⁷⁶

Aside from radioactive contamination, the cost of dismantling is another issue that has stirred public debate since the beginning of the decommissioning process. Estimates of the cost of dismantling have varied widely since the process began, prompting important questions with respect to their accuracy. With the faster timeline, 480 million euros is the projected cost, equaling about 647 million 2010 U.S. dollars.⁷⁷ In 2005, projections of underground storage costs—for only a fraction of the radioactive waste—varied from five to eighteen million euros.⁷⁸ To collect this enormous sum, EDF earmarks revenues to be saved for dismantling throughout all its plants' lifetimes. Dismantling early plants generally requires site-specific strategies, whereas newer plants are generally more standardized in their construction. Less streamlined dismantling efforts at older plants tend to be more expensive than more standardized measures at newer plants, where economies of scale can help to keep costs in check during dismantling.⁷⁹

Because of its early construction and its heavy-water technology that quickly became obsolete, the Brennilis plant demands a particular, and thus more expensive,

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⁷⁶ *Enquête Publique*, 54.
⁷⁷ Chartier, "Retour à l'herbe à Brennilis," 43.
⁷⁹ Ibid.
dismantling process. Bertrand Dubuis, manager of the Brennilis site, explains that at Brennilis “there is therefore a more significant cost for studying and devising methodologies that will later be useful for other plants.”

The continued pursuit of transparency at Brennilis is also valuable for underlining the importance of open communication throughout the dismantling process. Although the CLI was certainly the cornerstone of the transparency effort, several other initiatives can serve as models for firms in the process of dismantling. First, EDF developed important mechanisms of information sharing, including memos describing its decisions in detail. EDF began putting these memos online and circulating them among CLI members and local media. EDF’s maintenance of its website is also crucial to preserving its positive public image. Its Brennilis-specific internet site is highly organized and outlines clearly the most recent developments and documents related to the dismantling there. Educational material on nuclear technology and environmental health is also available on the site as evidence of EDF’s investment in its host communities.

In addition to these basic modes of open communication, EDF has allowed visits to certain parts of the plant site. This outreach aims to foster more positive public perception of a site that has historically been off-limits to non-employees. Elected officials, teachers, activists, and members of various organizations were all able to visit select parts of the site in 2008. EDF’s outreach extends, too, to its response to public inquiry. It aims to address the public’s concerns and questions through press releases, direct correspondence, and meetings.

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80 Chartier, "Retour à l'herbe à Brennilis," 43.
Transparency will also be crucial throughout Brennilis’s next step: envisioning a thriving community without the nuclear plant. EDF has articulated clearly its vision of a successfully dismantled Brennilis plant. This end result is the “‘green field’ stage, which is the ultimate goal of all operations of this type – in other words, the disappearance of every trace of the installation, and the return of the land concerned to unrestricted use.”

The last element of the ideal dismantling is deliberation about future site use. EDF dismisses the possibility of another nuclear facility on the Brennilis site and stresses the element of collaboration central to this planning effort. Various local actors must be involved in the decision-making process. Throughout the dismantling process, between 30 and 120 workers are needed. Some of the temporary workers will focus on attracting employers and businesses to Brennilis.

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82 Enquête Publique, 55.
V. Global Politics, Local Change

Having gotten caught up in France’s mid-century ambitions, Brennilis serves as an important illustration of how one municipality’s history is a product of much more than local politics and movements. On the local level, the heavy water power plant’s construction made sense for the employment opportunities it created and for the revenue it promised Brennilis. In the broader scheme of nuclear energy development, however, the construction was significant because of its experimental nature and the potential it represented. When the plant was decommissioned, the decision seemed to go against the desires of the Brennilis community; it was largely based on large-scale changes to the nuclear industry, rather than local interests. Brennilis’s story thus shows how close attention to the national and international level is important to a meaningful analysis of local history, given that these different circumstances are so deeply intertwined.

The nuclear industry intended to make Brennilis an exemplary case of dismantling, but the legacy of this plant is uncertain. Although its dismantling got off to a relatively tumultuous start, a neat resolution—a promising plan for reuse of the site and a smooth transition for the local economy—could salvage the site’s potential to serve as a model. According to EDF’s 2008 Sustainable Development Report, EDF plans to complete the dismantling of nine plants, including Brennilis’s, by 2035.83 Early nuclear plants had projected life spans of around 30 years, and many of the first

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plants have surpassed this expectation. Newer plants generally operate for about 40-60 years. Given the abundance of nuclear reactors around the world and a growing interest in building more of them, the issue of dismantling will be relevant for the foreseeable future.

As developed nations recognize the problems with fossil fuel dependence, world leaders scramble to find alternatives. Scrupulous evaluations of alternative energy sources will be key to the success of this quest. An expansion of nuclear energy production can be safe only if its development includes careful consideration of the final stage of a plant’s life. Bertrand Dubuis sees part of the mission at Brennilis “to demonstrate that the deconstruction of a plant is entirely a part of the nuclear cycle. It is also part of the utility’s responsibility vis-à-vis future generations.” Costs and implications of dismantling must be integrated into the earliest planning phases of nuclear plants. Far from ending at decommissioning, the impact of a nuclear reactor extends until the site and surrounding community contain essentially no trace of the plant.

As Brennilis’s story proves, though, meticulous planning is not enough to guarantee the complete success of a nuclear plant. Plant operators and local governments must make a serious effort to communicate clearly and consistently with host communities the risks and benefits of nuclear plants; an uninformed public is apt to seek ways to interfere with its plant’s functioning. Brennilis also shows, though, that even a combination of careful planning and public relations might not spell

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85 Chartier, "Retour à l'herbe à Brennilis," 43.
success for nuclear plants. Technological developments, global patterns, and major historical events will continue to shape the course of global nuclear power production and consumption. If nations are to avoid impulsive, dangerous responses to these broad changes, researchers must concentrate even more resources on the study of nuclear power, especially the final stages of a plant’s life. Otherwise, the risks are enormous; plant footprints will prove devastating—to the livelihood of communities, to the health of workers, and to the stability of the world as a whole.
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