The Pilgrim Nuclear Power Station Study: A Socioeconomic Analysis and Closure Transition Guide Book

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A SOCIOECONOMIC ANALYSIS AND CLOSURE TRANSITION GUIDE BOOK

Yale
UNIVERSITY OF MASSACHUSETTS AMHERST | AUGUST 2015

THE PILGRIM NUCLEAR POWER STATION STUDY: A SOCIOECONOMIC ANALYSIS AND CLOSURE TRANSITION GUIDE BOOK

A master's project presented by

Jonathan G. Cooper

Submitted to the Department of Landscape Architecture and Regional Planning at the University of Massachusetts Amherst in partial fulfillment of degree requirements for a

MASTER OF REGIONAL PLANNING

AUGUST 2015

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Acknowledgements

A number of individuals have assisted me with the completion of this project. For lending this project their support and interest, I would like to thank Lee Hartmann, AICP, Director of Planning and Development for the Town of Plymouth, and Pat Ciaramella, Executive Director of the Old Colony Planning Council. I would also like to thank Lauren Burm, Martin Cohn, Meghan Leahy, Joseph Lynch, and Joyce McMahon of the Entergy Corporation, who have taken the time to discuss several issues related to the project and its contents.

I am grateful to Chris Campany, Executive Director of the Windham Regional Commission in Vermont, who has been an invaluable source of additional information and professional perspective as he and his staff tirelessly serve the public interest throughout the closure process of Vermont Yankee.

Closer to home, my colleagues at the Institute for Nuclear Host Communities have been of great assistance to me, personally and professionally. I am lucky to have Jeff Lewis, Jennifer Stromsten, Paul Kostecki, and John Mullin alongside as we take our fledgling concern to higher heights.

Speaking of John, I must acknowledge my committee members, John Mullin and Henry Renski, for three reasons: to thank them for their substantial contributions to my learning; to state my admiration for their dedication to their students and to the public good; and to express my fondness for their good company.

Dedication

The briefest section of this document is most necessary: merely acknowledging my wonderful wife Katharine would have been insufficient. To you, and with you.

Abstract

THE PILGRIM NUCLEAR POWER STATION STUDY:
A SOCIOECONOMIC ANALYSIS AND CLOSURE TRANSITION GUIDE BOOK

AUGUST 2015

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Between February 2013 and December 2014, four communities hosting a nuclear power plant in the U.S. were faced with the sudden closure of the plant. These closures were largely attributable to market changes in the energy sector, driven by sustained growth in the natural gas industry. The rise of natural gas-fired plants has recently forced several of the nation's older coal-fired and petroleum-based power plants into early retirement, and nuclear industry analysts suspect that the nuclear closures of the past two years may be just the beginning of a similar trend.

Unfortunately, the extent of nuclear power plant closure impacts has rarely been investigated until after a plant's closure is announced, and only at the broader multi-county scale commonly found in economic analysis and forecasting. This project attempts to provide an improvement on both fronts: assessing an existing plant, with no plans to close, at local and regional scales. This project uses Pilgrim Nuclear Power Station as its subject of study. The plant, in Plymouth, Massachusetts, is licensed to operate until 2032.

After contextualizing nuclear closure and nuclear decommissioning, the project inventories the plant's key characteristics as a landowner and employer. It then identifies the plant's current socioeconomic contributions, details its operational impacts on other segments of the local and regional economy, and estimates how the plant's closure would affect the town and region. This project finds that the socioeconomic impacts of closure are so significant at local and regional levels that planning and economic development agencies cannot afford to wait until closure plans are announced to engage with the topic. I conclude with recommendations for the town and the region to build the knowledge, support, and momentum necessary to ensure the success of the long-term, multi-stakeholder, and cooperative approach the plant's eventual closure will require.

Summary of Impacts

This Guide Book estimates the socioeconomic impacts of the Pilgrim Nuclear Power Station ("Pilgrim Station") on the Town of Plymouth, the Old Colony Planning Council (OCPC), and neighboring cities and towns. The plant's direct impacts are identified first, followed by estimates of secondary impacts that come from the business and household spending caused by Pilgrim Station's expenditures. The Guide Book then estimates the impacts Pilgrim Station's closure would have on Plymouth and broader economies. This section of the report presents the Guide Book's major findings.

Pilgrim Station in 2014

Direct Impacts

$440 Million	**Wholesale value of electricity produced**
586	**Pilgrim Station workforce**
$77 Million	**Wages and benefits for plant workforce**
$60 Million	**Spending for goods and services in southeastern Massachusetts**
$17.4 Million	**State and local taxes and other payments**
$300K	**Charitable giving by Entergy and Pilgrim Station**

Secondary Impacts

$105 Million	**Additional economic output attributable to Pilgrim Station**
589	**Additional jobs created by Pilgrim Station**
$30 Million	**Wages and benefits paid by additional jobs**

Town of Plymouth Impacts

190	**Pilgrim Station employees living in Plymouth**
$24.9 Million	**Wages and benefits paid to plant employees**
$58.5 Million	**Value of real estate owned by plant employees**
$10.3 Million	**Municipal revenue from Pilgrim Station**
$950K	**Municipal revenue from employee property tax payments**
$23K - $61K	**Municipal revenue from biennial refueling outages**

Significant Findings

Pilgrim Station is a vital part of a regional economy that lags behind the state in key indicators of economic performance.

Pilgrim Station's most significant direct impact is the hundreds of well-compensated jobs it provides.

As of February 2015 there were 586 employees at Pilgrim Station, with a payroll of approximately $55 million and a weekly wage of $1,805. This represents 2.5% of the jobs held in Plymouth, and 5.3% of the wages paid in Plymouth. The average weekly wage at Pilgrim Station is 50 percent higher than the state average, and more than double the average wages in Plymouth, the OCPC, and Barnstable County. These jobs also provide considerable fringe benefits not included in the payroll total, likely raising the overall compensation value by 40 percent, to approximately $77 million.

Much of the Pilgrim Station workforce lives in the towns closest to the plant, which keeps much of the earned income within southeastern Massachusetts.

Nearly 85 percent of employees live in either Plymouth or Barnstable counties. By a wide margin, Plymouth is the most common place of residence, with 190 employees. Only five other towns are home to as many as 20 employees: Sandwich, Carver, Kingston, Bourne, and Marshfield. As a result, $17.8 million in Pilgrim Station wages is earned by Plymouth residents, and $7.2 million by other residents of the OCPC, $10.7 million by residents in SRPEDD towns, and $10.2 million by residents of the Cape. Adjusted to include benefits, Plymouth's total value approaches $25 million.

Pilgrim Station's non-payroll expenditures were approximately $77.5 million, and provided a substantial source of revenue to local businesses and municipalities.

More than 25 percent of Plymouth County businesses are in one of six industry subsectors that meet the procurement needs of nuclear power plants, likely accounting for the bulk of the estimated $60 million in procurement spending throughout Plymouth and Barnstable counties. Along with this spending, Pilgrim Station made more than $17 million in state and municipal payments for taxes and emergency preparedness funding. Approximately $10 million was paid to the Town of Plymouth alone, representing over 7 percent of the Town's total levy of $138.4 million for Fiscal Year 2015.

Pilgrim Station's direct impacts generate substantial secondary impacts throughout the region.

Pilgrim Station's operation stimulates additional economic activity in Plymouth and Barnstable counties.

The in-region spending by both Pilgrim Station vendors and plant employees creates an additional $105 million in regional economic output. Much like Pilgrim Station's direct economic output of $440 million supports 586 jobs with labor income of $77 million, the plant's secondary economic output of $105 million supports 590 jobs in the two counties, with earnings of nearly $30 million.

Spending by Pilgrim Station employees makes a significant impact on industries outside the nuclear power plant supply chain.

Nuclear power plant employees enjoy relatively high wages and comprehensive health care packages. As a result, hospitals and other health practitioners' offices in the region benefit significantly from the Pilgrim Station workforce. Household spending is also disproportionately high at real estate establishments, restaurants, and financial institutions.

Nuclear power plant employment is stable and well-compensated, enabling employees to attain home ownership.

Based on current median home values, the property owned by Pilgrim Station employees living in these ten towns is over $135 million, with $58.5 million in Plymouth alone. The residential property taxes generated by this group reach $1.95 million annually, with $908,000 collected by Plymouth. This is augmented by motor vehicle excise tax payments, which are estimated to reach $45,000 per year in Plymouth, based on the substantial number of employees living there.

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Part One: Introduction

1.1 Project Background and Goal

On June 18, 2014, Moody's Investors Service released a report entitled, "US Nuclear and Coal-Fired Power Plant Retirements to Jolt Some Local Governments." The purpose of the report was to identify the ten local governments across the country with the highest levels of credit exposure in the event of a power plant closure or downsizing. One of the municipalities identified was the Town of Plymouth, Massachusetts, where the General Obligation Bond rating is Aa2 (high quality and very low credit risk), and where the Pilgrim Nuclear Power Station (Pilgrim Station) has operated since 1972. While Pilgrim Station is licensed to operate until 2032, and there have been no indications or discussions suggesting that the plant will close before that time, the report raised a series of challenging questions. What will happen when the plant closes? Will the municipal impacts be limited to bond ratings? What other aspects of life in Plymouth are affected by the operation of Pilgrim Station, and would therefore be affected by its closure? Is nuclear power plant closure at all different form other types of plant closure?

These are the questions this project attempts to address. Surprisingly, they have rarely been asked in any nuclear host community. A number of industry-sponsored economic impact analyses for nuclear power plants exist, but they focus on national, state, and multi-county level impacts, leaving closure questions and local-scale questions aside. The goal of this project, then, is to create a Guide Book specific to Plymouth and its region that identifies the critical socioeconomic issues related to nuclear power plant closure, quantifies local-level direct and indirect impacts, pinpoints possible strategies to address the challenges of closure, and clarifies the roles for local and regional planning agencies in the closure process.

1.2 Issues and Context

A nuclear power plant is a remarkable entity. Its reactor generates much more than electricity, and produces much more than spent fuel and steam: the plant also creates jobs, business and household spending, municipal revenue, charitable donations, and seemingly endless public conflict and concern. It is one of the biggest cogs in its local economic engine, but it mostly operates out of view. It is built to withstand massive stresses, but with a current maximum lifespan of sixty years, it is not built to last. It is a

major source of local employment, but it is not a major source of local identity: America has steel towns, lumber towns, coal towns, college towns, resort towns, military towns, and many more. But it doesn't have nuclear towns.

This is partly explained by an unusual dynamic in many communities that host or have hosted a nuclear power plant: considerable reliance on the plant's local and regional socioeconomic benefits, combined with relatively limited public awareness of that role. In many instances, it is only when the plant owners announce closure plans that much consideration is given to the local and regional impacts of nuclear power plant closure. As the full extent of the plant's local socioeconomic footprint comes into view, a host community realizes that the closure can lead to much more than a loss in tax revenue and electrical generation capacity. Unfortunately, the narrative that accompanies nuclear plant closure at higher levels of government does not take this footprint into consideration.

From a regulatory perspective, a nuclear power plant in the United States closes permanently when its nuclear reactor(s) enter the decommissioning phase. The final step in that phase is the release of all property from the regulatory oversight of the U.S. Nuclear Regulatory Commission (NRC). For the plant's owners, employees, contractors, ratepayers, investors, and regulators, it is the end of a long, expensive, and labor-intensive process. For those communities and regions hosting a nuclear reactor, however, the narrative continues after the decommissioning phase draws to a close.

From a local perspective, decommissioning is only one part of the "post-operational" phase, in which a community is forced to confront the socioeconomic impacts of plant closure. Although the regional socioeconomic impacts of a nuclear power plant's construction and operation have been studied extensively, far less attention has been paid to the local impacts of plant operation, and nearly none has been given to the regional or local impacts of plant closure. Furthermore, although the NRC has a thorough and complex process for ensuring that nuclear decommissioning is safely and successfully carried out, there is no system in place for assisting host communities and regions with the socioeconomic impacts of power plant closure. In short, nuclear power plant closure is a well-understood engineering and logistical event, but a poorly understood economic and social event.

Compared with other responses to local economic destabilization, this is a significant gap. In the last half of the 20th century, the federal government often assisted communities affected by military, industrial, and environmental issues. In 1961, the Office of Economic Adjustment was created within the Department of Defense. Its purpose was to assist communities adversely affected by base closures or other program changes, and it has remained the key federal contributor to local entities throughout the Base Realignment and Closure (BRAC) process. In the 1970s, as the deindustrialization of the United States became the subject of intense academic and professional study, major federal and state initiatives were established to both prevent the loss of jobs and productivity, and to create social safety nets where facilities had closed. Lastly, in 1980, Congress passed the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) to confront the legacy of our industrial past and its presence in many downtowns and waterfronts, creating the Superfund program that is key to site reuse today.

However, without an established program bringing local, state, and federal officials together with plant ownership to focus on post-closure outcomes for nuclear host communities, local and regional entities wishing to begin the process before plant closure is at hand must do so alone. Unfortunately, the mutually antagonistic relationship between the nuclear power industry and the well-organized anti-nuclear movement can make plant operators wary of sharing much information with local officials. Adding to the complexity is the sudden nature of nuclear power plant closure: while the NRC licensing process currently allows reactors to operate for up to 60 years, not once has a plant's closure coincided with the expiration of its license. Instead, the decisions are the results of energy competition, site maintenance regulations, plant materials, political action, and government regulation. In 1991, for example, upgrades to the NRC's standards for plant operations led to the decision to close the Yankee Rowe Nuclear Power Plant in Rowe, Massachusetts the following year, even though the plant had more than eight years left on its original operating license. In 2013, Kewaunee Power Station in Kewaunee, Wisconsin was closed due to the falling prices of natural gas, despite having received a twenty-year license extension just five years before.

As a result, host communities are left to their own devices following a closure announcement, largely watching from the sidelines as the plant's productive era winds down and decommissioning begins. High-paying jobs leave the region, municipal revenue drops, and a major economic engine for direct, indirect, and induced impacts grinds to a halt. It falls to local and regional authorities to make the next move, with a considerable

degree of difficulty: a good deal of the plant's reusable infrastructure is removed during decommissioning; land that has been decontaminated is still "former nuclear land" in the eyes of the public and the marketplace; and a portion of the site often contains storage facilities for spent nuclear fuel, to remain for an indeterminate period of time. This is a situation that calls for emergency economic and community development triage; instead, the prescription is "patient, heal thyself." Whether local and regional planning and economic development officials have the professional expertise to do so is simply left to chance.

This arrangement can have serious consequences. In August 1995, the Town of Haddam was in the middle of a property assessment dispute with the owner of the Connecticut Yankee nuclear power plant. At the time, the plant was expected to operate until its license expired in 2007. The plant was the town's largest employer and taxpayer, and accounted for 59 percent of the town's grand list. When asked by a local newspaper about recent efforts to expand the local tax base, such as the addition of a new sandwich shop and video store, a town selectman said, "we probably won't get serious about any economic development until we've lost the income from [Connecticut Yankee]." It shut down just 15 months later, in December 1996.

On June 18, 2014, Moody's Investors Service released a report entitled, "US Nuclear and Coal-Fired Power Plant Retirements to Jolt Some Local Governments." The purpose of the report was to identify the ten local governments with the highest levels of credit exposure in the event of a power plant closure or downsizing. One of the municipalities identified was the Town of Plymouth, Massachusetts, where the General Obligation Bond rating is Aa2 (high quality and very low credit risk), and where the Pilgrim Nuclear Power Station (Pilgrim Station) has operated since 1972. While Pilgrim Station is licensed to operate until 2032, and there have been no indications or discussions suggesting that the plant will close before that time, the report raised a series of challenging questions. What will happen when the plant closes? Will the municipal impacts be limited to bond ratings? What other aspects of life in Plymouth are affected by the operation of Pilgrim Station, and would therefore be affected by its closure? Is nuclear power plant closure at all different form other types of plant closure?

Part Two: Closure and Decommissioning

Contents and Summary

Part Two describes the broader issues of nuclear power plant closure and nuclear power plant decommissioning in three sections. Section One identifies the characteristics of nuclear power plant closure that distinguish it from other plant closures in the energy and manufacturing sectors. Section Two explores the industry challenges that have contributed to the decisions to close four nuclear plants since 2013. Section Three describes the process of reactor decommissioning, and addresses the similarities and differences between the two options most common for commercial reactor decommissioning: immediate dismantlement (DECON), and deferred dismantlement (SAFSTOR).

In summary, nuclear power plant closure and decommissioning present challenges that are not easily countered by existing best practices regarding facility closures. In addition to location and workforce particularities, there is no federal entity with an industry-specific mandate to help communities facing nuclear power plant closure. Due to an unfortunate lapse in federal policy regarding spent fuel storage, spent fuel is currently stored on site indefinitely, resulting in widespread public and industry frustration with regulatory authorities. This impasse has contributed to the recent trend in decommissionings, in which plants owned by private companies have expressed a clear preference for allowing a site to sit unused for decades while radiation decays naturally before undertaking the bulk of the active dismantlement.

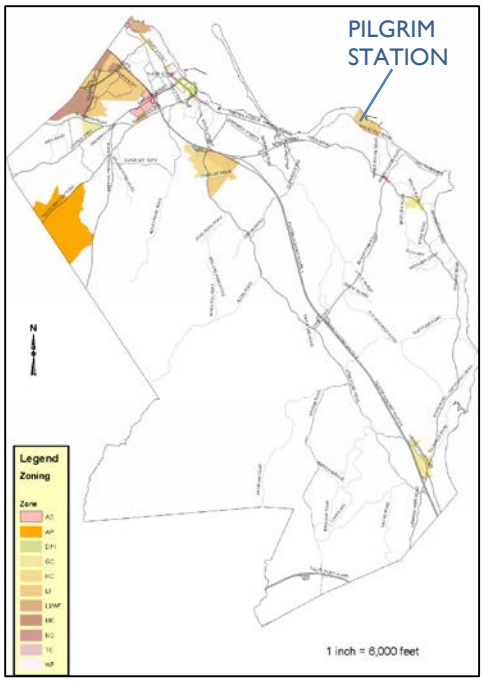
2.1 Nuclear Power Plant Closure

From some perspectives, nuclear power plant closure presents the same challenges as any other kind of major closure: jobs lost, workers dislocated, property values reduced, and industrial parcels vacated. However, a closer look at the characteristics of nuclear power plant closure reveals a typology distinct from both manufacturing and non-nuclear power plant closures.

LOCATION

By design, nuclear power plants are out of the way. In the interests of caution and risk management, they are distant from valuable infrastructural assets like highway on-ramps, active commercial hubs, and adjacent industrial areas. For decades now, such elements have been essential traits of successful industrial land use development: most industrial operations depend on a steady stream of raw materials provided via just-in-time delivery, and co-locating with similar enterprises can help firms share costs and reduce costs for external services. **Figure 2.1**, taken from a 2012 land use study in Plymouth, identifies commercial and industrial zones in the town. Most parcels have direct highway or airport access. Pilgrim Station sits apart, miles from both.

FIGURE 2. 1: COMMERCIAL/INDUSTRIAL ZONING



Source: Town of Plymouth

WORKFORCE

With respect to the energy industry, nuclear power plant workforces are exceptionally large, and highly specialized. The average power plant employs fewer than 70 people, far below the nuclear power plant average of 950. In fact, for every 1,000 megawatts (MW) of capacity, a nuclear plant provides an average of 500 jobs, well in excess of other sources, such as coal (190 jobs); hydropower (120 jobs); wind (90 jobs); and natural gas (60 jobs). The specialized nature of nuclear energy employment also means that instead of developing new skills to find alternative employment in the region, many of these well-compensated workers (and their families) will look to relocate to other nuclear plants in the event of a closure. See Section 3.2 for more information on workforce characteristics.

CLEANUP

Unlike other industrial closure cleanups, in which some existing structures and components can remain intact for future use, nuclear decommissioning requires the dismantling of nearly all structures on site. It can take anywhere from five years to five decades, and cannot begin until the plant owner has enough money to pay for the entire project. In most cases, this means reaching the Nuclear Regulatory Commission's acceptable maximum radiation dose of 25 millirem per year from the decommissioned site

(slightly less than half of the radiation received from a single abdominal x-ray). In Massachusetts, however, where the cleanup standard is an appreciably more restrictive 10 millirem per year, project costs would likely be higher from the outset. See **Appendix A** for more information on cleanup standards.

ASSISTANCE

The NRC is tasked solely with ensuring operator adherence to federal regulations regarding the safe construction, operation, maintenance, and decommissioning of nuclear reactors. There is no federal agency tasked with directly or indirectly assisting communities confronting nuclear plant closure. Unlike communities facing a military base closure, natural disaster, or manufacturing relocation, nuclear host communities are often left on their own. Without federal guidance, it is difficult for host communities and plant operators to determine expected impacts, appropriate preparations, and mutually beneficial outcomes. Some states have responded by entering into negotiations with plant operators that have announced closures, but with mixed results.

SPENT FUEL

FIGURE 2. 2: SPENT FUEL STORAGE, CONNECTICUT YANKEE

Source: Connecticut Yankee

There is no analogue in any other industry to the problem of storing spent nuclear fuel and other high-level radioactive waste on-site indefinitely. Every regulation, investment, and development made in nuclear energy since the dawn of commercial reactor era has been based upon the presumption that the federal government would meet its obligations to provide a site for the permanent storage of high-level radioactive waste and spent fuel. It has not done so. Plant operators and host communities are now faced with the likelihood that spent nuclear fuel will remain stored and monitored on-site for decades, as has been the case at most of the decommissioned nuclear power plants around the country. With no resolution to this issue in the offing, a number of lawsuits have been filed in state and federal courts (see **Appendix B**). This holding pattern creates significant friction between the public and the plant operators, erodes the

trust of all parties in the federal agencies involved, and leaves a mark upon the land that prospective investors find difficult to ignore.

As a result, current trends in economic revitalization, site reuse, and workforce development can have a hard time finding a best-practices foothold in mitigating the socioeconomic impacts of nuclear closure. In many other cases, grant applications can be written, facilities can be repurposed, workforces can be retrained, restoration can be accelerated, and funding can be obtained. A closed nuclear power plant is not so easily redeveloped, and the still-vacant parcels of land at former nuclear power plant sites in New England and beyond are a testament to this. Below, **Table 2.1** identifies the current status of the nine plants to have been permanently shut down between 1989 and 1998, as well as the years the plants shut down, and cleanup was completed (not including spent fuel storage). The early experience at Fort St. Vrain, in which a site was decommissioned completely and back to generating revenue as a gas plant in less than a decade, has proven to be the exception and not the rule. See **Appendix C** for two case studies.

Table 2.1: Current Site Status of Nuclear Plant Closures, 1989-1998

	Closure	Cleanup	Major Site Reuse Initiatives
Shoreham (NY)	1989	1994	None
Fort St. Vrain (CO)	1989	1993	Gas plant, operational since 1996
Rancho Seco (CA)	1989	2009	Gas plant, operational since 2006
Yankee Rowe (MA)	1991	2007	None
Trojan (OR)	1992	2006	None
Connecticut Yankee	1996	2004	None: gas plant proposal failed in 2002
Maine Yankee	1997	2005	None: coal plant proposal failed in 2007
Big Rock Point (MI)	1997	2006	None
Zion (IL)	1998	Ongoing	None, cleanup in progress

Source: Author's review

2.2 Nuclear Industry Challenges

There are two significant issues facing the US nuclear power industry: increasing plant costs and diminishing reactor lifespans. Their influence can be seen in the recent and upcoming plant closures that are indicative of the difficult position the US nuclear industry is in. Three nuclear power plants were permanently shut down in 2013: Kewaunee, in Wisconsin; San Onofre, in California, and Crystal River, in Florida. A fourth, Vermont Yankee, was closed in 2014, and officials at Oyster Creek Nuclear Generating Station in New Jersey have announced their intention to close that plant in 2019. These pressures are felt most acutely at the 29 nuclear power plants operating in deregulated energy markets, as Pilgrim Station is. Referred to as "merchant" plants, these plants compete with other energy generating facilities to sell power to utility companies through a series of short-term contracts. While plants in regulated markets are facing the same challenges, the structure of the marketplace provides some insulation against the market adjustments described below.

Plant Costs

There are three main categories for plant operating costs: fuel costs, operation and maintenance (O&M) costs, and capital costs. Fuel costs account for the procurement of enriched nuclear fuel, as well as the reactor refueling process which shuts down the reactor every 18-24 months for approximately five weeks while spent fuel is removed and new fuel is loaded in. O&M costs account for ordinary expenditures, such as payroll, regulatory fees, taxes, routine equipment maintenance, and contributions to reactor decommissioning funds. Fuel costs and O&M costs refer to ongoing costs, and are often referred to as "production costs." The third category, capital costs, refer to major investment expenditures. At existing nuclear power plants, capital costs account for the acquisition of land, the construction of new facilities, upgrades to mechanical and electrical systems, and safety retrofitting. In the aftermath of the Fukushima disaster in 2011, the NRC has required plant owners to make significant investments in system safety and security to maintain their operating licenses. At Pilgrim Station, this meant responding to elevated standards for containment vents, spent fuel pool instrumentation, and mitigation strategies in case of a loss of power at the plant. These plans were submitted in 2013 and 2014, and have been subject to continued oversight and implementation since. In addition, the NRC requested reevaluations of the plant's emergency communications systems, staffing levels, and resistance to earthquakes and flooding. Pilgrim Station was one of ten

nuclear power plants identified by the NRC as a high priority facility for seismic reevaluation, and the plant's report was filed with the NRC in March 2014. Pilgrim Station was also one of twenty plants given three years to complete its flooding reevaluation, due to the substantial complexity of the site's characteristics. This report was due on March 12, 2015, and will likely be under NRC review for the next year.

Advocates of nuclear power have long touted its low production costs relative to the fossil-fueled plants which account for 67 percent of the nation's electricity generation. (Among the energy sources that make up the remaining 33 percent, nuclear power is by far the largest, with 19 percent of the national total.) This advantage has always been tied to nuclear energy's extremely low fuels costs. Unfortunately for these advocates, the production cost difference is nowhere near as strong as it was in recent years, as the sudden surge in domestic shale gas production has shifted the math considerably. Comparing 2008 and 2012 values of average fuel costs (in mills per kilowatt hour) for major U.S. investor-owned plants, the magnitude of the change becomes clear. At gas turbine plants, fuel costs fell drastically from 64.23 to 30.45; at fossil-fueled steam plants, costs fell moderately from 28.43 to 24.17; and at nuclear plants, costs rose moderately from 5.29 to 7.08.

The increase in fuel costs would be less stressful for the nuclear industry if the markedly low fuel prices weren't offset by the industry's comparatively high O&M costs. According to industry analysts, O&M expenditures have increased in recent years in response to enhanced regulatory policies, elevated labor costs, and more intensive maintenance for older reactors (see below). Following the fuel costs comparison above, comparing changes to average O&M costs between 2008 and 2012 illustrates the effects. At gas turbine plants, O&M costs fell moderately from 6.49 to 5.22; at fossil-fueled steam plants, O&M costs rose slightly from 7.31 to 7.72; and at nuclear plants, costs rose moderately from 16.09 to 18.4.

As **Table 2.2** shows on the following page, the production costs (fuel costs plus O&M costs) were much more favorable to nuclear energy in 2008 than they were in 2012, as plummeting fuel prices for gas turbines changed the landscape significantly. However, a number of factors prevent nuclear power plants from streamlining operations to remain competitive. Given the complexity of nuclear power generation and the regulatory requirements to manage its risks, the industry is not in a position to cut costs, trim workforces, or postpone maintenance to a significant extent.

Table 2.2: Changes in Production Costs by Energy Industry, 2008 and 2012

	Fuel Costs			O&M Costs			TOTAL COSTS		
	2008	**2012**	Change	**2008**	**2012**	Change	**2008**	**2012**	**Change**
Gas Turbines	64.23	30.45	-52.6%	6.49	5.22	-19.6%	70.72	35.67	**-49.6%**
Fossil Fuel Steam	28.43	24.17	-15.0%	7.31	7.72	5.6%	35.74	31.89	**-10.8%**
Nuclear	5.29	7.08	33.8%	16.09	18.4	14.4%	21.38	25.48	**19.2%**

Source: US EIA Electric Power Annual 2012, Table 8.4

Reactor Lifespan

Unlike the facilities of other energy industry sectors, nuclear power reactors have an established upper limit to their lifespan. According to NRC guidelines, a reactor may operate for no more than 60 years. With no new reactors built since 1996, analysts have been paying close attention to the impacts that approaching mandatory reactor retirement has on operational decisions. A firm end date means that each passing year represents one fewer year for ownership to earn a return on any investments. Fourteen reactors reached 40 years of operation in 2014, bringing to 37 the total number of reactors with fewer than 20 years left to operate. Eleven of these are at single-reactor plants, Pilgrim Station included, which will have to shut down entirely.

The decision to close Oyster Creek in 2019 illustrates the reasoning behind the early retirement. The nation's oldest operating nuclear reactor, the original license for Oyster Creek's single reactor was set to expire in 2009. In the course of obtaining its 20-year extension, state officials pushed the plant's owners, Exelon, to build cooling towers that would lower the temperature of the water leaving the plant. To avoid incurring the cost of a major project that did not extend the life or the productivity of the plant, Exelon agreed to forgo the final ten years of the license extension. In exchange, the state agreed to allow the plant to operate until 2019 without the cooling towers.

2.3 Nuclear Decommissioning

When a reactor is removed from service permanently, it enters the costly and time-consuming process of decommissioning. The process calls for the return of the site to a neutral radiological state within 60 years of closure. Upon completion, the Nuclear Regulatory Commission releases the site from regulatory control. It is important to note that this process does not address the presence of an Independent Spent Fuel Storage Installation (ISFSI), which plant owners have been required to build in order to store used

nuclear fuel until the federal government secures an appropriate permanent repository. These are considered stand-alone facilities, which have their own NRC-issued licenses and must be maintained by plant owners according to NRC regulations.

Regulatory Framework

The NRC identifies three phases for nuclear power plant decommissioning: initial activities, major decommissioning and storage activities, and license termination activities. Although the NRC mandates at least two public meetings (conceivably more than fifty years apart), at no point in the NRC's process is a plant owner required to determine, plan for, or mitigate the local socioeconomic impacts of the decommissioning.

INITIAL ACTIVITIES

This phase includes a series of filings and reports certifying the cessation of operations, the removal of nuclear fuel from the reactor, and the Post-Shutdown Decommissioning Activities Report (PSDAR). The PSDAR, which must be filed within two years of the shutdown, details the decommissioning approach selected, as well as a site-specific cost estimate and timeline. The NRC mandates one (1) public meeting sometime after the PSDAR is submitted to the NRC.

MAJOR ACTIVITIES

This phase describes the bulk of the decommissioning operations, such as removing major structural components. There are three approaches to large-scale commercial reactor decommissioning:

> **DECON** (immediate dismantling), which begins demolition and decontamination shortly after closure. DECON often takes 5-10 years.
>
> **SAFSTOR** (deferred dismantling), which allows radioactivity to decay before major activities commence. SAFSTOR often takes 50-55 years.
>
> A combination of DECON and SAFSTOR, based on site-specific arrangements.

A fourth option, **ENTOMB**, encases the site's radioactive components in concrete to decay naturally. It is a viable option for small test reactors with relatively brief operational lives, but is not suited to decommissioning a large-scale nuclear power plant.

LICENSE TERMINATION ACTIVITIES

This phase includes the submission of a License Termination Plan (LTP) by the plant's owner to the NRC. This report includes details for any remaining dismantlement or site remediation activities, and must be filed within two years of the expected release of the site from NRC oversight. The NRC mandates one (1) public meeting when the NRC receives the LTP. After implementing the LTP, the owner submits a Final Status Survey Report (FSSR) requesting that the operating license either be terminated (if spent fuel is not stored on-site) or reduced to the size of the spent fuel storage installation.

If the FSSR is approved, the NRC agrees that the site is suitable for release from regulatory oversight. The goal is often Unrestricted Use, the NRC's version of a greenfield. Since 2000, however, the NRC has reviewed and approved requests for the partial release of a reactor site for unrestricted use prior to LTP approval. In 2003 for example, 431 acres of Maine Yankee's "buffer" land was transferred to a developer for the purposes of constructing an industrial park two years before the facility was decommissioned (see **Appendix C**).

Comparing SAFSTOR and DECON

In order to determine the best decommissioning option for a given reactor, owners review a number of factors. Some of these are characteristic of the methods themselves, while others are specific to a given plant's context. On the following page, **Table 2.3** identifies several.

Table 2.3: Factors Affecting Decommissioning Strategies

	DECON – Immediate Dismantling	**SAFSTOR** – Deferred Dismantling
Technical	Removes radioactive waste hazards to community	Radioactive decay reduces hazards to workers
	Takes advantage of existing best management practices	Allows for advances in decommissioning technology
	Must account for transportation of hazardous materials	Must account for the long-term presence of hazardous materials
Economic	Significant up-front costs can be discounted over long term	Project cost and complexity lowered as radioactivity decays
	Avoids uncertainty of future market conditions, inflation, and potential natural disasters	Allows decommissioning fund to grow substantially between closure and dismantling
Social	Allows for site reuse without stagnation	Allows more infrastructure to remain after cleanup
	Site remains active in immediate aftermath of closure, transmitting active-use benefits to the region	Avoids public opposition associated with transportation for off-site disposal
Ownership	Public utilities can spread costs among ratepayers over the long term	Investor-owned utilities can secure shareholder confidence by deferring costs

Source: Adapted from Pasqualetti (1990)

Since 1989, thirteen commercial nuclear power plants have shut down. On the following page, **Table 2.4** arranges these plants by year of closure, and identifies the decommissioning method as well as the status of the project. As the table shows, the preference for decommissioning where plant shutdown is concerned has shifted completely to SAFSTOR in recent years. (In the case of a multi-reactor power plant decommissioning only one reactor while others remain operational, it is very common to put the reactor into SAFSTOR mode.)

Table 2.4: Decommissioning Methods and Status at Closed Facilities

Name	Location	Closure	Method	Status	Notes
Shoreham	East Shoreham, NY	1989	DECON	1994	Never Operational
Fort St. Vrain	Platteville, CO	1989	DECON	1993	ISFSI and Gas Plant
Rancho Seco	Herald, CA	1989	DECON	2009	ISFSI and Gas Plant
Yankee Rowe	Rowe, MA	1991	DECON	2007	ISFSI Only
Trojan	Rainier, OR	1992	DECON	2006	ISFSI Only
Connecticut Yankee	Haddam, CT	1996	DECON	2004	ISFSI Only
Maine Yankee	Wiscasset, ME	1997	DECON	2005	ISFSI Only
Big Rock Point	Hayes Township, MI	1997	DECON	2006	ISFSI Only
Zion	Zion, IL	1998	Mixed	Ongoing	Delayed DECON
Crystal River 3	Crystal River, FL	2013	SAFSTOR	Ongoing	ISFSI
Kewaunee	Carlton, WI	2013	SAFSTOR	Ongoing	ISFSI
San Onofre	San Diego County, CA	2013	SAFSTOR	Ongoing	ISFSI
Vermont Yankee	Vernon, VT	2014	SAFSTOR	Ongoing	ISFSI

Source: Nuclear Regulatory Commission

Project Costs

Decommissioning costs routinely reach into the hundreds of millions of dollars. For example, construction of the single-reactor Yankee Rowe plant was completed in 1960, at a cost of $39 million. Decommissioning was completed in 2007, at a cost of $608 million, more than twice the inflation-adjusted amount of the construction cost. The NRC therefore requires plant operators to maintain access to the minimum amount of money necessary for decommissioning activities throughout the life of the reactor, a figure determined by NRC formulas. Some early estimates pegged the cost of decommissioning at 10-15 percent of construction costs, but more recent estimates have pushed the upper bound to 25 percent of modern-day construction costs. Current federal estimates of decommissioning costs are lower, in the $300 million to $400 million range, which nevertheless represents a significant revision of the $105 million to $135 million estimate the agency provided into the 1990s.

Recent cost estimates are well beyond the federal figures. Industry analysts have begun making site-specific cost estimates for future decommissionings in the $600 million range. In 2008, TLG Services, a decommissioning planning and consulting firm acquired

by Entergy in 2000, estimated that it would cost $914.5 million to decommission Pilgrim Station by 2048 if the plant was put into SAFSTOR in 2012. In fact, billion-dollar decommissioning procedures have been forecast by EnergySolutions, the group responsible for decommissioning the two reactors at Zion in Illinois, and by the owners of the recently closed, single-reactor Kewaunee Power Station in eastern Wisconsin. According to the PSDAR filed with the NRC for Vermont Yankee, Entergy expects the SAFSTOR decommissioning to cost $1.24 billion (in 2014 dollars), with major dismantling delayed until 2068.

Workforce Adjustments

Whether the plant operator chooses SAFSTOR or DECON, the plant workforce undergoes a similar adjustment, with four reductions occurring between five operational phases. The first reduction, between the time of the closure announcement and the actual shutdown, represents a workforce response, as employees examine other options: retirement, continued employment in the nuclear industry at other nuclear facilities or in the private sector, or a transfer to other utility work or some other industry. Closure announcements are generally made six months to a year before final shutdown. The shutdown is often timed to coincide with the end of the current fuel cycle, when the plant ordinarily goes offline for refueling. The most recent closure, at Vermont Yankee, was announced in August of 2013, a full 16 months before the plant was shut down at the end of December 2014. The remaining reductions are a function of each phase's employment requirements. On the next page, **Table 2.5** describes these phases, as well as their likely durations before and after shutdown. Also on the next page, **Figure 2.3** illustrates the similarity of staffing reduction plans at two New England plants, which were shut down more than 15 years apart, and decommissioned with different methods. Maine Yankee, shut down in 1997, was the larger plant of the two. It was decommissioned with the DECON option. Vermont Yankee, shut down in 2014, had a smaller workforce and output, and is currently in the early stages of the SAFSTOR mode. In both cases, within one year of shutdown the workforce had been trimmed by about half.

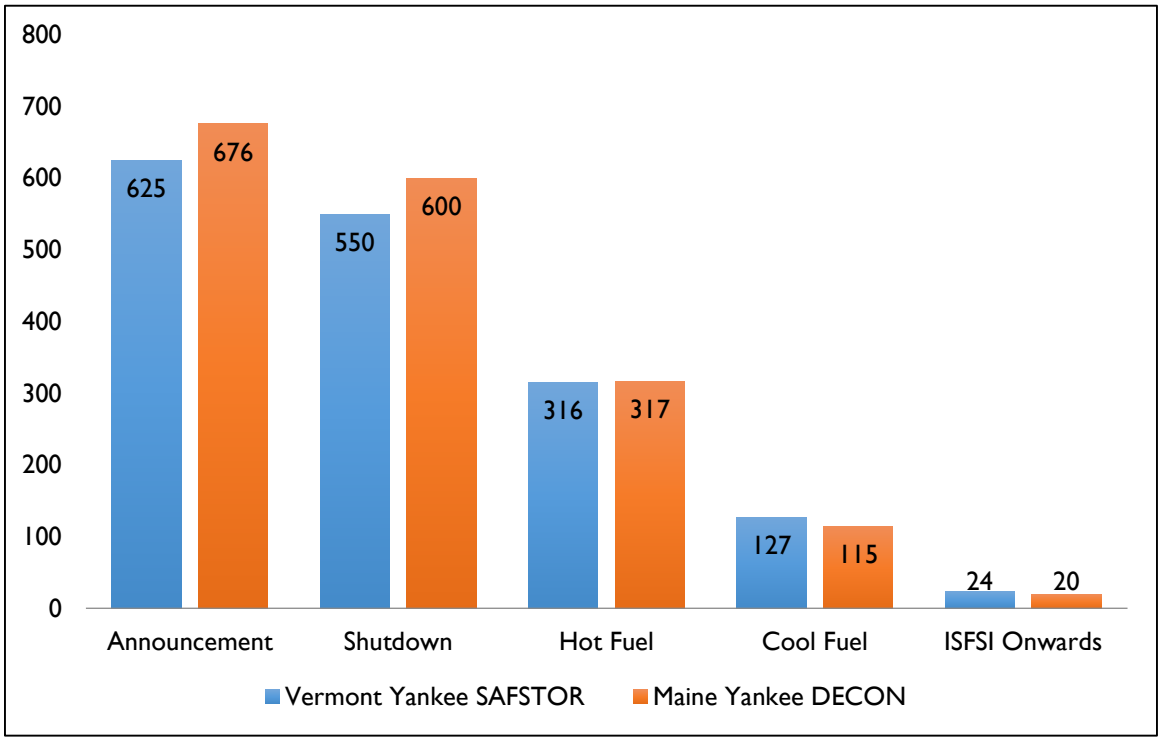
However, it is important to bear in mind that **Figure 2.3** does not include any decommissioning contractors. Under the SAFSTOR approach, their presence will be minimal for decades as the plant and its components undergo natural radioactive decay. In 2068, for example, Entergy expects the total site staffing at Vermont Yankee to jump from 24 to approximately 325 for the five years or so it will take to complete the

decommissioning, with contractors performing most of the on-site work. By contrast, the DECON approach requires a significant contractor presence on site shortly after shutdown, to begin the dismantlement: at Maine Yankee, for example, there were as many as 300 contractors on site in 2002, outnumbering the plant employees nearly 3:1.

Table 2.5: Employee Reductions Phases in Nuclear Plant Closure

Announcement	**Shutdown**	**Hot Fuel**	**Cool Fuel**	**ISFSI Onwards**
6-12 mos. prior		Years 1 and 2	Years 3-6	Years 6 +
Normal operational total at the power plant.	Operational total as the plant goes offline. Reductions represent employee retirement or relocation after announcement.	Workforce after plant ceases to produce electricity. Operations now limited to managing spent fuel, including "hot fuel" recently removed from reactor.	Workforce after all hot fuel has sufficiently cooled for storage with remainder of spent fuel in underwater storage.	Workforce after all fuel has been prepared for dry cask storage in on-site ISFSIs.

FIGURE 2. 3 : SAFSTOR AND DECON EMPLOYEE REDUCTION PATTERNS



Source: Entergy Corporation (Vermont Yankee); EPRI (Maine Yankee)

Part Three: Pilgrim Station

Contents and Summary

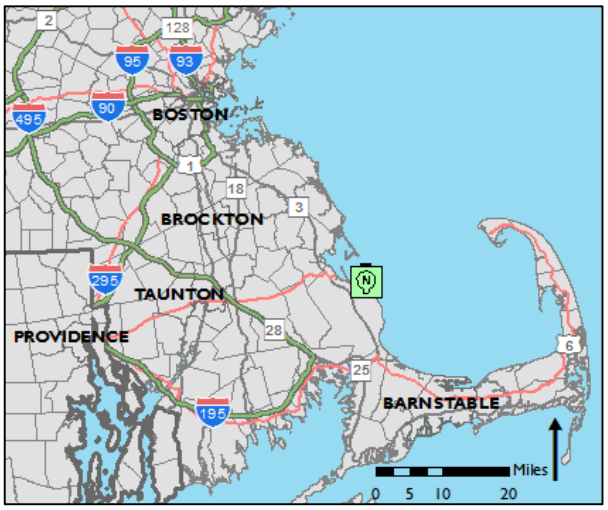
Part Three provides an inventory of Pilgrim Station. Section One describes Pilgrim Station as a landowner and physical entity. This section describes the plant's location and property holdings; its regulatory relationship with surrounding towns; characteristics of the power plant site; and a brief encapsulation of the plant's history and license status. Section Two describes Pilgrim Station as an employer, identifying changes in staffing levels and occupational characteristics between 2005 and 2015, and providing a current residential distribution of Pilgrim Station employees by town.

In summary, Pilgrim Station is a single-reactor 690 MW power plant owned by the Entergy Corporation, licensed to operate until 2032. It sits on a coastal parcel of 134 acres, the northernmost portion of Entergy's 1,675 acres of contiguous land. Pilgrim Station provides 586 full time jobs, nearly three quarters of which belong to members of utility and security workers' unions. Approximately half of the workforce lives in one of the five towns within ten miles of the plant, 190 of which are in Plymouth alone. Over 84 percent of employees live in either Plymouth or Barnstable counties, and only three live outside of Massachusetts.

3.1 Site and Operations

Pilgrim Station is in Plymouth, Massachusetts, on the shores of Cape Cod Bay. The major cities of Boston and Providence lie 38 miles to the north and 44 miles to the west, respectively. Within Plymouth, the plant is 5.4 miles east of Town Hall, and 4.6 miles from the nearest highway on-ramp to Massachusetts Route 3. Portions of two seaside residential areas are within one mile of Pilgrim Station: the Rocky Point neighborhood to the west, and the village of Manomet to the southeast. **Figure 3.1** provides the regional context for the plant, which lies between Greater Boston and Cape Cod.

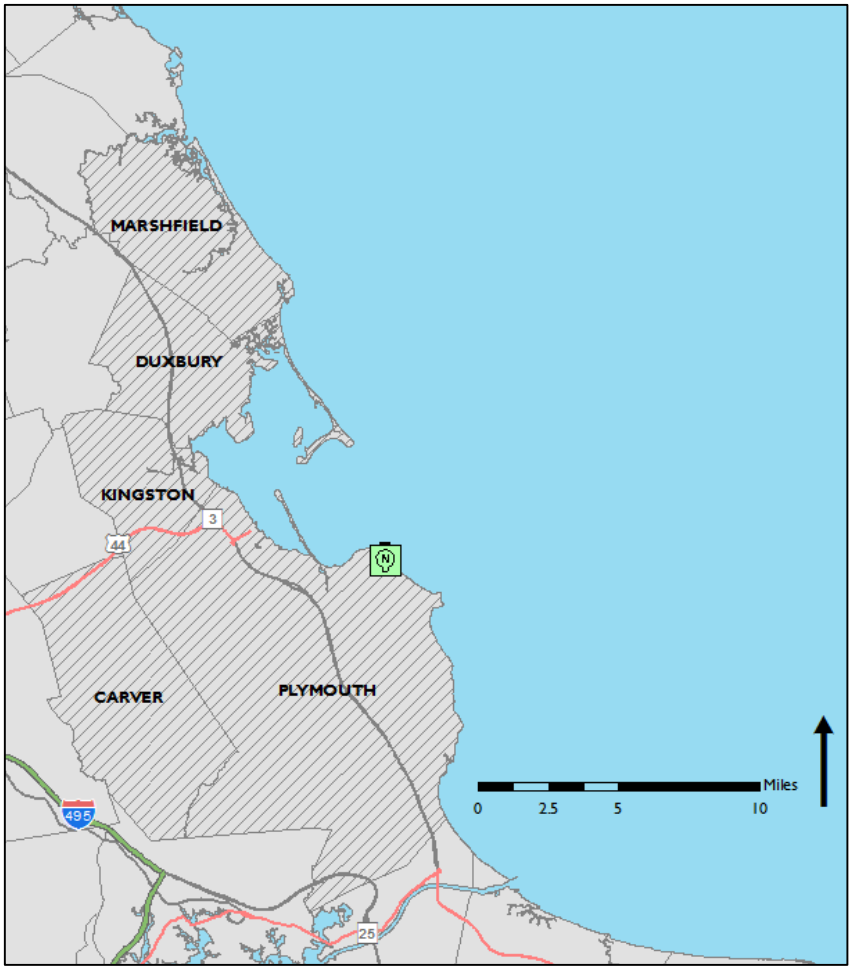
FIGURE 3. 1: REGIONAL CONTEXT OF PILGRIM STATION



Source: MassGIS

Emergency Planning Zone (EPZ)

FIGURE 3. 2: THE EMERGENCY PLANNING ZONE



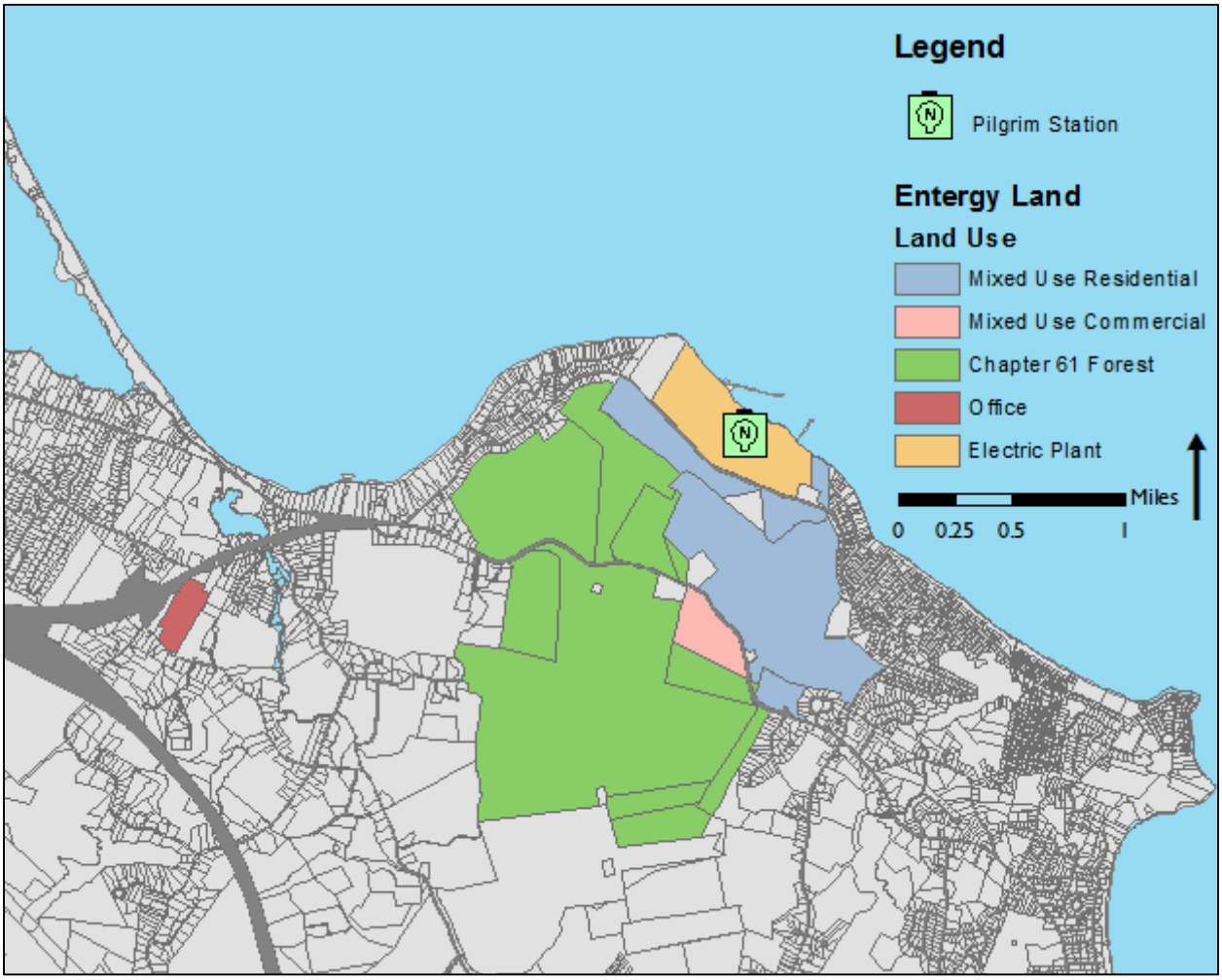
Source: MassGIS

All nuclear power plants are required to provide specialized emergency planning services and detailed evacuation plans for residents within a five-mile radius of the plant. **Figure 3.2** identifies the five Massachusetts towns within the EPZ: Plymouth, Kingston, Duxbury, Carver, and Marshfield. The EPZ includes all of Plymouth, Kingston, and Duxbury; the portion of Carver east of MA Route 58; and the small segment of Marshfield south of MA Route 139. The Pilgrim Station EPZ is a fairly straightforward geographic unit: five municipalities in one county. By contrast, Vermont Yankee's EPZ included 18 municipalities in a tri-county area that included the states of Vermont, New Hampshire, and Massachusetts. Elsewhere in the country, power plants frequently have to contend with an array of civic entities along the municipal spectrum, such as townships, boroughs, villages, unincorporated lands, and so on. The simplicity of the Pilgrim Station EPZ will likely work to the advantage of its constituent towns should they wish to negotiate jointly with plant ownership in the future.

Properties

The plant's principal structures occupy a single parcel of 133.6 acres, zoned for light industry. This parcel is less than one-tenth of the contiguous 1,675-acre site owned by Entergy Nuclear Generating Company. The remainder of the site is primarily forested upland, and includes the peak of Manomet Hill, the highest point in Plymouth County. After acquiring the plant and site in 1999, Entergy placed 1,530 of these acres into an active forest management plan pursuant to Chapter 61 of the General Laws in conjunction with the state Department of Conservation and Recreation. Furthermore, the land is subject to a Restrictive Covenant that prevents any development of the land for any residential purposes under the current Payment in Lieu of Taxes Agreement (PILOT) between Entergy and the Town of Plymouth, described more fully in Part Four. Entergy's only other property in the town is the Chiltonville Training Center, which sits on a 24-acre site four miles west of the plant. The extent of these land holdings are visible in **Figure 3.3**, below.

FIGURE 3. 3: ENTERGY-OWNED PROPERTIES IN PLYMOUTH WITH LAND USE DESIGNATION



Source: Plymouth Assessor's Database; MassGIS

There are two parks near the plant. Cleft Rock Park is owned by the Town of Plymouth, and is surrounded by Entergy land north of State Road. The park is 8.7 acres, with some hiking trails, a picnic area, and unusual rock formation more than a dozen feet in height. When the weather is right, visitors standing on the rock can catch a clear view down to Cape Cod Bay. Emerson Park is on White Horse Road, one-fifth of a mile south of the intersection with Rocky Hill Road. The park is operated by the Plymouth Recreation Department, and is home to two tennis courts and one of Plymouth's 13 youth baseball fields. Emerson Park was built on power plant land in 1976, and has remained the property of the plant owners since.

In addition to these holdings, Entergy leases two properties in Plymouth, both related to emergency preparedness and off-site management. The first, known as the Joint Information Center, is at 71 Armstrong Road, just one mile from the junction of Route 44 and Route 3. Owned by Duxbury Associates, the facility is primarily used as an emergency preparedness media center and training facility, and is zoned for light industrial uses. The second property, the Emergency Operations Center, is at 44 Obery Street. The Center is near the center of town, in a building owned by Plymouth County.

Pilgrim Station Site

Pilgrim Station's boiling water reactor (BWR), designed by General Electric and built by the Bechtel Corporation, has a generation capacity of 690 megawatts (MW). The reactor has averaged approximately 5.4 million megawatt hours (MWh) of power generation per year over the past decade. Other plant components on site include the turbines, steam tower, office buildings, fuel storage facilities, switchyard, water intake structure, and boat/barge landing for sea access. An ISFSI is under construction, which is the subject of ongoing litigation in Massachusetts Land Court.

Pilgrim Station is connected to the electric grid by two 345 kilovolt transmission lines that travel in a 300 foot-wide NSTAR Right of Way corridor along the eastern portions of Entergy's property. The lines share a single set of towers that travel five miles from the Pilgrim Station switchyard to the Jordan Road substation. One of the transmission lines joins a previously existing line at the substation, while the other travels another 2.2 miles to the Snake Hill Road substation in Myles Standish State Forest. The total 12.2 miles of transmission line connecting Pilgrim Station to the grid are owned and operated by NSTAR, which also maintains the approximately 260 acres the Right of Way amounts to.

History and License

In 1967 the Boston Edison Company, a regulated public utility, began construction on Pilgrim Station. Construction was completed five years later, and the plant began supplying electricity to the public on December 1, 1972. Boston Edison owned and operated Pilgrim Station until 1999, when the utility began the process of merging with Commonwealth Energy System to form NSTAR. As a precursor to the merger, Boston Edison sold Pilgrim Station that year to its current owners, Entergy Corporation. This marked the country's first sale of a public utility's nuclear power plant to a private entity. The NRC approved the transfer of Pilgrim Station's operating license from Boston Edison to Entergy Nuclear Generation Company on April 29, 1999.

Shortly after taking ownership of the plant, Entergy began the process of obtaining a license renewal for Pilgrim Station. The application was submitted to the NRC in January 2006, the start of a multi-year sequence requiring additional reports, impact statements, and safety evaluations to be generated and approved. The renewed license was issued in May 2012, and expires on June 8, 2032: 60 years to the day after the initial license was granted to Boston Edison.

3.2 Employee Characteristics

The Pilgrim Station workplace is predominantly male, and significantly unionized. Data provided by Entergy for this study stated that of the 586 employees at Pilgrim Station as of February 2015, only 15 percent are women, and 71 percent are union members. This level of labor organization is well above the national average of 30 percent for nuclear power plants. The 416 employees belong to one of three active union shops at Pilgrim Station, each representing a distinct workforce component at Pilgrim Station.

Workforce Composition

Two shops are locals of the Utility Workers Union of America (UWUA). The Braintree-based UWUA Local 369 is the larger of the two, representing employees at twelve utility companies across Massachusetts. Among its 2013 total of 2,961 members were approximately 250 Pilgrim Station radiation technicians, power plant operators, maintenance mechanics, and other laborers. The smaller Local 590 is a professional/engineers union based out of Manomet in Plymouth. It is limited to engineers working at Pilgrim Station, with a 2013 membership total of 66. Also in Manomet is Local 25 of the United Government Security Officers of America (UGSOA).

The local, which is limited to Pilgrim Station's security service personnel, counted 87 members in 2013.

In February 2005, there were 703 Pilgrim Station employees, of whom 574 were Entergy employees, and 129 were baseline contractor employees. In February 2015, Entergy provided an employee-only headcount of 586, and stated that contractor totals were unavailable. The similarity between the non-contractor total of 574 and 586 seems to suggest that the workforce has been relatively stable, perhaps even implying that the contractor levels have remained similar, but events since the 2005 headcount suggest that the composition has shifted significantly.

At the time of the previous headcount, more than 100 of the baseline contractors were security guards employed by the Wackenhut Corporation, a security services company with numerous nuclear plant security contracts across the globe. In 2006, Entergy canceled its contract with Wackenhut, and offered to hire the existing security guards as Entergy employees. The security force accepted the offer, and began working directly for Entergy in January 2007. (Not coincidentally, this was the first year UGSOA Local 25 filed an annual report with the Department of Labor.) A review of union filings reveals that Local 590, the engineers union, has essentially remained steady since Entergy added the security personnel to their workforce. However, a letter from Local 369, filed with the NRC the same month that Entergy hired the former Wackenhut contractors, states that the local represented nearly 400 Pilgrim Station employees at the time, nearly 70 percent of Entergy's non-contractor workforce. The conclusion, therefore, is that the plant simply has fewer operations and maintenance workers than it used to: today the number is 43 percent.

Age and Education

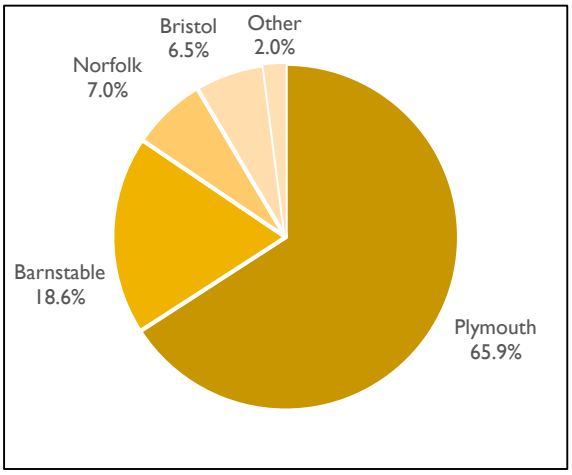
One of the defining features of the civil nuclear workforce is that it is rapidly aging. With an average employee age in the mid-fifties, more than one third of the nation's approximately 60,000 nuclear power plant workers will reach retirement age in the next five years. At 55 years old, the average nuclear power plant worker is older than approximately 76 percent of Plymouth's residents. Aware of the unique needs of nuclear employers, and the emergency that a shortfall of human capital would represent, the industry has responded by implementing partnerships between the industry, universities, trade schools, and training facilities over the past decade.

The high degree of specialization required by nuclear power plants means that existing and potential employees benefit from specific educational systems. Nuclear energy is in need of those with bachelor's degrees in nuclear engineering, computer engineering, mechanical engineering, civil engineering, and physics, and two year technical degrees in related fields. Recognizing this uncommon demand, many nuclear power plants, including Pilgrim Station, have partnered with technical schools and colleges to offer two and four year specialized degrees for nuclear labor preparation. Pilgrim currently partners with Massachusetts Maritime Academy and UMass Lowell to offer customized courses and certificates, and Entergy has made regular charitable donations to Mass Maritime since 2007 (see Section 4.1 for more information).

Residential Distribution

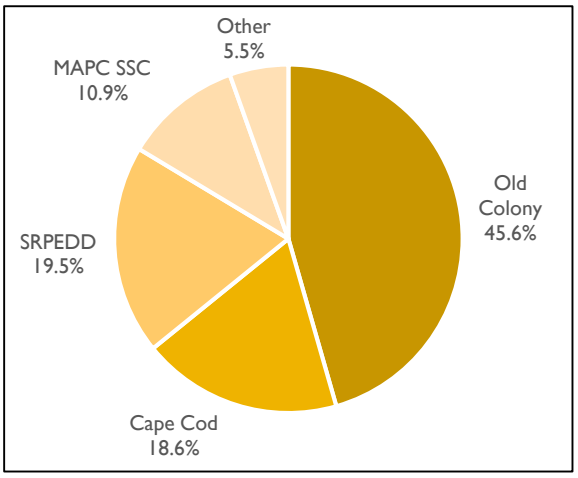
According to a residential distribution provided by Entergy, only three employees live outside of Massachusetts, all in Rhode Island. As **Figure 3.4** shows, Plymouth County (386 employees) and Barnstable County (109 employees) are the two most common counties of residence, accounting for nearly 85 percent of the Entergy's employees at Pilgrim Station. **Figure 3.5** shows the employment shares for the area's three regional planning agencies, as well as the portion living in the South Shore Coalition subregion of the Metropolitan Area Planning Council (MAPC SSC). (The employment totals for Duxbury and Pembroke, which are part of both the OCPC and the SSC, have been allocated to the OCPC.)

FIGURE 3. 4: 2015 EMPLOYEE RESIDENCE BY COUNTY



Source: Entergy Corporation

FIGURE 3. 5: 2015 EMPLOYEE RESIDENCE BY RPA



Source: Entergy Corporation

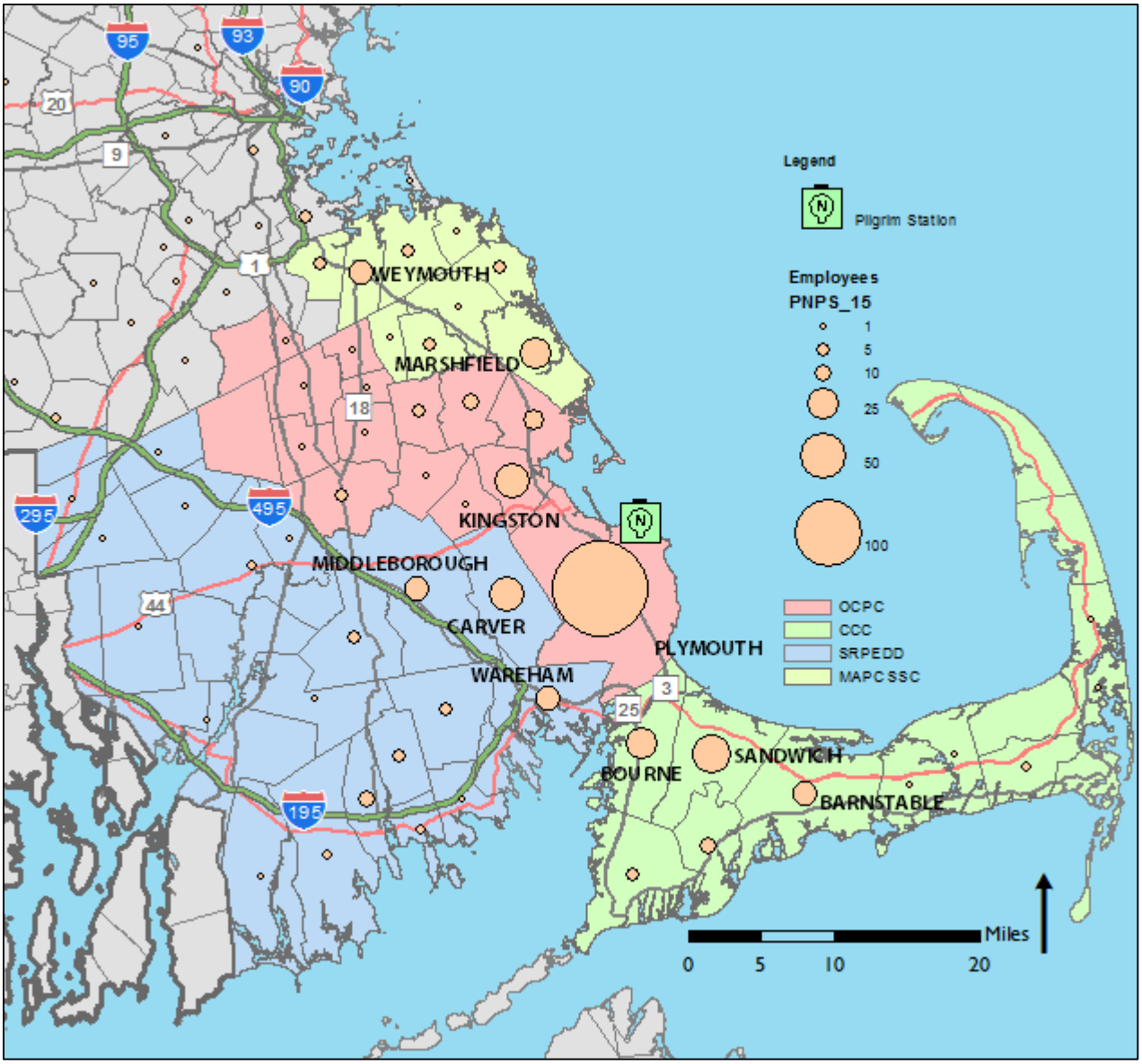
The workforce is also markedly concentrated in the towns closest to the plant. There are Pilgrim Station employees living in 74 municipalities, yet there are nearly as many living in the five towns of the EPZ (292 employees) as there are in the non-EPZ towns (294 employees). This distribution is detailed in **Table 3.1** and **Figure 3.6**, below. By a wide margin, Plymouth is home to the greatest number of employees, with 190. Outside the EPZ, the greatest concentration of employees is in the towns of the Upper Cape. The local nature of the workforce means that not only is Pilgrim Station an important source of economic productivity for the region, it is also an important source of income, household spending, and property taxes. The implications are examined in Part Four.

Table 3.1: 2015 Residential Distribution of Entergy Employees with EPZ Designation

Geography	Total	Component	Subtotal	Community	Headcount
Within Emergency Planning Zone	292	Host Community	190	Plymouth	190
		Other OCPC Towns in EPZ	45	Kingston	32
				Duxbury	13
		EPZ Towns outside OCPC	57	Carver	33
				Marshfield	24
Outside Emergency Planning Zone	294	CCC Towns	109	Sandwich	40
				Bourne	25
				Barnstable	19
				Mashpee	10
				Other CCC	15
		SRPEDD Towns (without Carver)	81	Wareham	15
				Middleborough	15
				New Bedford	8
				Other SRPEDD	43
		MAPC SSC Towns (without Marshfield)	40	Weymouth	15
				Scituate	6
				Braintree	5
				Other SSC	14
		OCPC Towns (outside EPZ)	32	Pembroke	9
				Bridgewater	7
				Hanson	5
				Other OCPC	11
		Other Massachusetts	29	Quincy	5
				Other MA	24
		Rhode Island	3	All RI	3

Source: Entergy Corporation (2015)

FIGURE 3. 6: 2015 RESIDENTIAL DISTRIBUTION OF ENTERGY EMPLOYEES WITH RPA DESIGNATION



Source: Entergy Corporation; MassGIS

Part Four: Impacts of Pilgrim Station

Contents and Summary

Part Four introduces the impacts of Pilgrim Nuclear Power Station on Plymouth and the surrounding region, in three sections. Section One is limited to the operational impacts directly attributable to Pilgrim Station itself: plant output; employee wages; procurement spending; taxes and other municipal payments; and charitable contributions. Section Two addresses some economic impacts indirectly attributable to Pilgrim Station's operations: the spending of the temporary workforce that refuels Pilgrim Station's reactor for approximately one month every two years; the local real estate taxes paid by Pilgrim Station employees annually; and the local industries most impacted by the household spending of employees. Section Three postulates the permanent closure of Pilgrim Station, and evaluates the cascading local and regional impacts that would accompany plant shutdown.

In summary, a traditional account of the direct and secondary impacts of Pilgrim Station's operation on the economies of Plymouth and Barnstable counties in 2014 would reach $545 million of economic output. This economic activity supported approximately 1,175 jobs and $107 million in income; nearly 1,100 jobs and $95 million in income accrued to the two-county region. Direct regional expenditures totaled $136 million: $60 million in purchases from regional vendors; $65 million in wages and benefits for the 495 Pilgrim Station employees living in either of the two counties; $10.7 million in municipal payments, and $0.3 million in charitable giving. Pilgrim Station's secondary impacts on the two counties were estimated to at $105 million in economic output, which created approximately 590 jobs earning nearly $30 million in income.

Plant closure, therefore, would extend far beyond the direct impacts of the plant's operations alone. Some of the hardest hit industries would be the region's healthcare providers, real estate agencies, banking institutions, restaurants, and additional utility companies. Unlike the region's considerable tourism and agriculture industries, these jobs are neither seasonal nor cyclical, and they provide the region with substantial economic stability.

4.1 Direct Operational Impacts

As an enterprise owned and operated by a Louisiana-based Fortune 500 company, and powered by a fuel source that is not locally produced, it stands to reason that a good deal of Pilgrim Station's output will leave the region. However, given that nuclear power plants pay as well as they do, employ as many people as they do, and require as many services as they do, robust local and regional economies are often able to retain a substantial portion of a plant's O&M costs.

Electric Output

As is the case for many power plant impact analyses, the value of Pilgrim Station's electricity generation is the starting point for the calculations that follow. Based on preliminary figures and the methodology described below, Pilgrim Station's 2014 output was approximately $440 million. This is the plant's total output, and it represents a "whole pie," before slices of varying size are allocated to corporate and shareholder benefits, operations and maintenance, fuel costs, and other components. Every socioeconomic benefit that flows from Pilgrim Station to regional and local levels is tied to the market value of its power generation, as well.

Pilgrim Station's total economic output varies from year to year, however. As a nuclear power plant, Pilgrim Station goes offline every 24 months to replenish the reactor's fuel supply and transport spent nuclear fuel to cooling pools. These outages last for approximately 30 days, reducing the plant's total annual electrical output (see the following section for more information on refueling workforces). Furthermore, as a merchant plant operating outside of a regulated market and competing with other power suppliers, the value of Pilgrim Station's electricity is subject to significant variation.

To approximate the value of the electricity produced by Pilgrim Station in a given year, information from the U.S. Energy Information Administration (EIA) on plant capacity and regional power prices was combined with information on efficiency and output from the International Atomic Energy Agency (IAEA). According to the EIA, the plant operated at 99.2 percent capacity in 2010, generating 5.9 million megawatt-hours (MWh) of electricity. That year, the weighted average wholesale price in New England (referred to by the EIA as NEPOOL MH DA LMP Peak) was $55.93 per MWh, which yields an estimated $331 million of electricity. The following year, however, was very different: a planned outage for nuclear refueling diminished output to 5.1 million MWh, and the

average market price per MWh fell to $42.40. Under this approximation scheme, the total value of Pilgrim Station's 2011 output would be a more modest $215.6 million. **Table 4.1** contains information for more recent years, as well, which shows the impacts of the recent increases in New England's electricity prices.

Table 4.1: Value Electric Output at Pilgrim Station, 2010-2014

	Efficiency	Total MWh	Avg $/MWh	Estimated Value
2014 (preliminary)	98.6	5,769,150	$76.25	$439,897,688
2013 (Refuel Apr-May)	72.9	4,330,643	$65.17	$282,219,773
2012	98.2	5,859,540	$42.33	$248,033,391
2011 (Refuel Apr-May)	85.5	5,085,220	$42.40	$215,631,635
2010	99.2	5,917,813	$55.93	$330,954,060

Source: US EIA (2013); IAEA Power Reactor Information System (2014)

Employment and Wages

Pilgrim Station provides a substantial number of permanent, full-time, and well-compensated jobs. According to information provided by Entergy for this study, there are currently 586 full time Entergy employees at Pilgrim Station. This places the plant within the 20 largest employers in the OCPC, and makes it the third-largest employer in Plymouth behind the Town of Plymouth and the former Jordan Hospital (now known as Beth Israel Deaconess Hospital-Plymouth).

Due to the specialized skill sets required for many jobs in the industry, wages at nuclear power plants exceed averages. Entergy's payroll of $55 million translates to an average salary of $93,857 for the 586 employees at Pilgrim Station in February 2015. This is comparable to both national averages and the earnings at nearby plants like Seabrook Station, where the average salary is approximately $94,500. Most importantly, it compares quite favorably with local and regional income levels, more than doubling the values at both scales. As **Table 4.2** shows on the following page, Pilgrim Station jobs account for just 0.45 percent of the jobs in the OCPC region, but 0.95 percent of the wages; in Plymouth the total is 2.5 percent of the jobs, and 5.3 percent of the wages paid (all according to 2012 values).

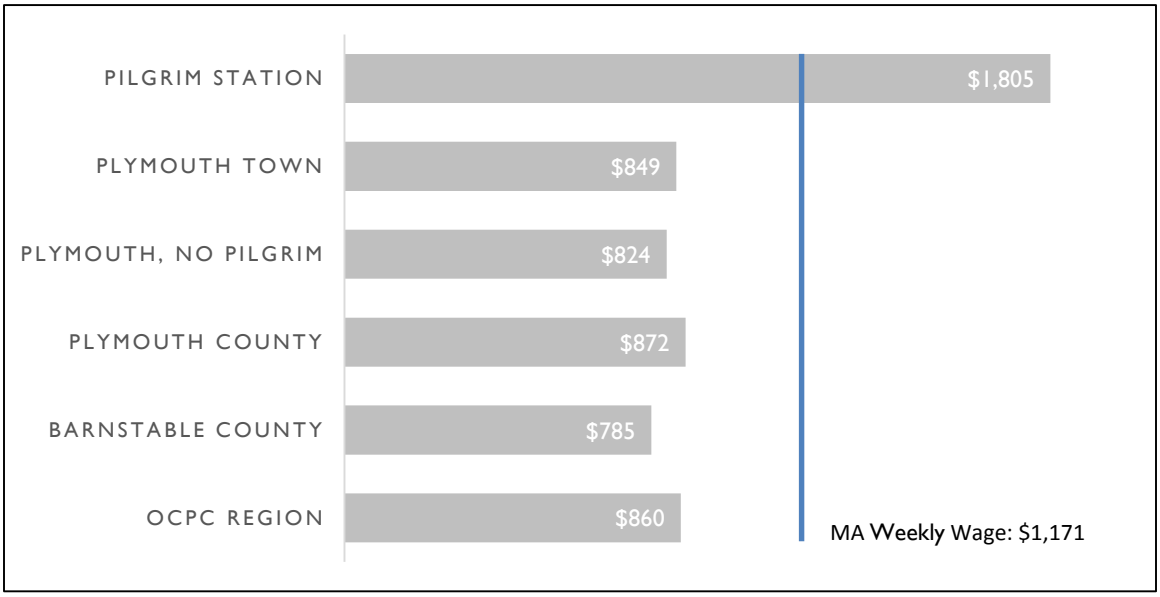
Table 4.2: 2015 Job and Wage Shares of Pilgrim Station, by Region

Jobs	Share	Pilgrim Station	Share	Wages
23,536	2.49%	Plymouth Town	5.29%	$1,038,922,395
129,788	0.45%	Old Colony	0.95%	$5,803,798,710
175,957	0.33%	Plymouth County	0.69%	$7,978,935,618

Source: Old Colony Planning Council (2014)

In fact, the presence of Pilgrim Station raises the average weekly wage paid in Plymouth by more than three percent, from $824 to $849. **Figure 4.1** contains six average weekly wages for comparison: Pilgrim Station; Plymouth; Plymouth without Pilgrim Station; Plymouth; Barnstable County; Plymouth County; and the OCPC region. With the exception of Pilgrim Station, all weekly wage averages lagged behind the state average of $1,171, represented in the figure by a blue line.

FIGURE 4. 1: COMPARISON OF AVERAGE WEEKLY WAGES, PILGRIM STATION AND SURROUNDING AREAS



Source: Old Colony Planning Council (2014); US Bureau of Labor Statistics

While it is unlikely that residential distribution is a perfect indicator of wage distribution, it helps give a sense of where the payroll is going. Applying the data in Table 3.1 to payroll, **Table 4.3** below presents the estimated accrual of annual wages within the four regional planning agency service areas, identifying the top three towns in each area. Over 45 percent of the payroll stays in the OCPC region, with nearly one-third remaining in Plymouth alone. Of particular note is the segment directed towards Cape Cod: it is by no means the largest number, but it represents year-round work in the area's least prosperous and least populous region.

The final row indicates the portion of each total that is within each RPA's largest three towns. It is meant to give a sense of the extent to which the workforce and wages are clustered within the region. That the OCPC's level would approach 90 percent is no surprise, given the high level of Pilgrim Station employees in Plymouth. Most interesting is the difference between SRPEDD and Cape Cod, where comparable numbers of employees have arranged themselves in markedly different patterns. One of the likeliest explanations is the difference in more extensive highway access in SRPEDD communities: few Cape residents who work at Pilgrim Station live very far from Route 6.

Table 4.3: Estimated Wage Distribution, 2015

Old Colony		SRPEDD		Cape Cod		South Shore	
Plymouth	17.8 million	Carver	3.1 million	Sandwich	3.8 million	Marshfield	2.3 million
Kingston	3 million	Wareham	1.4 million	Bourne	2.3 million	Weymouth	1.4 million
Duxbury	1.2 million	Middleboro	1.4 million	Barnstable	1.8 million	Scituate	0.6 million
Other	3 million	Other	4.8 million	Other	2.3 million	Other	1.8 million
Totals	**$25 million**		**$10.7 million**		**$10.2 million**		**$6.1 million**
In Top 3	88 percent		55 percent		77 percent		70 percent

Source: Author's calculations

Expenditures for Goods and Services

In October 2014, a procurement engineer at Pilgrim Station wrote an open letter to a local newspaper in support of the plant. In it, he described an annual economic impact of over $125 million, a sum of the plant's payroll, taxes, contributions, and the purchases of goods and services. Entergy declined to provide this study with purchase data of any kind, but given that the plant's payroll ($55 million), local tax arrangement ($10 million), and annual donation totals ($350,000) are known quantities, we can infer that Pilgrim Station's annual expenditures in the region are approximately $60 million. It is unclear

whether the "region" described is Plymouth County, Greater Boston, or the whole of southern New England, but it provides a useful starting point.

Although such a total represents a fairly high level of non-payroll regional spending for a nuclear power plant, it is not unreasonable. Nuclear power plants spend millions of dollars each year on a variety of goods and services. Due to the highly specialized nature of nuclear power generation, a regional economy will only be able to supply a fraction of what a power plant needs, but regional strengths in certain fields can be rewarded. **Table 4.4**, below, details the extent to which this is the case. For example, in 2011, non-payroll purchases at Seabrook Station totaled $54 million within a tri-county region, and $179 million outside the region. That same year, non-payroll purchases at Diablo Canyon totaled $22 million in a two-county region, and $277 million outside the region. Where regional economies match poorly with nuclear power plant needs, the in-region spending can be minuscule: non-payroll purchases at Duane Arnold Energy Center totaled $2.2 million in a two-county region, and $84 million outside the region.

Table 4.4: Regional Accrual of Non-Payroll Expenditures

		Goods & Services ($ millions)		
Plant	State	Region	Non-Region	Region PCT
Diablo Canyon	CA	$21.8	$277.0	7.3%
Duane Arnold	IA	$2.2	$76.7	2.8%
Seabrook	NH	$54.4	$147.5	26.9%

Source: Nuclear Energy Institute

Plant spending reaches a number of industries, from caterers to petrochemical manufacturers. A review of industry research and promotional materials developed by regional chambers of commerce indicated that nuclear plant expenditures tend towards firms providing engineering, environmental, and other technical consulting services; chemical, machinery, and electronics manufacturing; utility systems construction and wiring; durable goods wholesale and rental; and general business support services. These needs can be grouped into six broad industry sectors, shown in **Table 4.5** on the following page. The table includes the relevant employment and wage information from 2012 in Plymouth County for the industries described above, aggregated at the 3-digit NAICS scale. As the table shows, over one quarter of Plymouth County jobs are in one of the sectors identified, suggesting that the local economy is capable of meeting some of Pilgrim Station's annual expenditures.

Table 4.5: Nuclear Power Plant Vendor Sectors in Plymouth County, 2012

		Employment		Earnings	
	Subsector Name	Jobs	Share	Wages	Relative
Specialty Sectors	Professional and Technical Services	6,913	3.9%	$69,108	1.52
	Advanced Manufacturing	4,927	2.8%	$63,332	1.40
	Specialty Construction	8,311	4.7%	$62,660	1.38
	Durable Goods Wholesale and Leasing	2,900	1.6%	$69,316	1.53
General Sectors	Administrative and Support Services	6,273	3.6%	$36,556	0.81
	Food Services	16,979	9.6%	$16,172	0.36
Subtotals	**Specialty Sectors**	**23,051**	**13.1%**	**$65,575**	**1.45**
	General Sectors	**23,252**	**13.2%**	**$11,999**	**0.26**
	Non-Vendor Industries	129,654	73.7%	$45,993	1.01
Total	Plymouth County	175,957	100%	$45,344	1.00

Source: Massachusetts Department of Labor ES-202; Author's calculations

While the employment levels are evenly distributed between specialty services and general services, the table shows that the wages are not: earnings in the four specialty sectors are more than five times higher than the earnings in the two general sectors. Significantly, these specialty sectors exceed the average annual earnings in Plymouth County by nearly 50 percent.

The six sectors reach a variety of full-time, part-time, and seasonal industries. **Table 4.6**, on the following page, identifies some of the specific industries within the specialty and general sectors. Wage averages from 2012 within Plymouth County are provided for the specific 4-digit NAICS subsectors that these industries belong to, to demonstrate the earnings variation within each sector. For example, within the Advanced Manufacturing sector are eleven industries that provide services or products relevant to the nuclear power industry. These can be grouped into three subsectors of advanced manufacturing: chemicals and plastics manufacturing, fabricated metal products and machinery manufacturing, and computer and electronic products manufacturing. As the table shows, workers in the digital subsector earn nearly $20,000 per year more than workers in the metal and machinery subsector.

Table 4.6: Nuclear Power Plant Vendor Industries in Plymouth County, 2012

SUBSECTORS	NAICS	Component Industries
Professional and Technical Services		
Scientific & Technical Services: $79,093	541330	Engineering Services
	541620	Environmental Consulting Services
	541690	Other Scientific and Technical Consulting Services
Advanced Manufacturing		
Chemical & Plastics: $66,248	325110	Petrochemical Manufacturing
	325180	Other Basic Inorganic Chemical Manufacturing
Fabricated Metal Products & Machinery: $57,876	332313	Plate Work Manufacturing
	332410	Power Boiler and Heat Exchanger Manufacturing
	332420	Metal Tank (Heavy Gauge) Manufacturing
	332811	Metal Heat Treating
	332911	Industrial Valve Manufacturing
	333611	Turbine and Turbine Generator Set Units Manufacturing
Computers & Electronic Products: $77,718	334517	Irradiation Apparatus Manufacturing
	334519	Other Measuring and Controlling Device Manufacturing
	335991	Carbon and Graphite Product Manufacturing
Specialty Construction		
Utility Systems & Wiring: $67,426	237130	Power and Communication Line and Related Structures Construction
	238210	Electrical Contractors and Other Wiring Installation Contractors
Durable Goods Wholesale and Leasing		
Industrial Machinery Sales & Rentals: $65,702	423510	Metal Service Centers and Other Metal Merchant Wholesalers
	423830	Industrial Machinery and Equipment Merchant Wholesalers
	423990	Other Miscellaneous Durable Goods Merchant Wholesalers
	532490	Commercial and Industrial Machinery and Equipment Rental and Leasing
Administrative and Support Services		
Office & Grounds Services: $31,123	561311	Employment Placement Agencies
	561612	Security Guards and Patrol Services
	561730	Landscaping Services
	561790	Services to Buildings - Exterior Maintenance
Food Services		
Entire Sector: $16,202	722320	Catering
	722511	Full-Service Restaurants and Drinking Places

Source: Massachusetts Department of Labor ES-202; Author's calculations

Taxes and Municipal Payments

Pilgrim Station's annual state and local payments amount to approximately $17.4 million. **Table 4.7** itemizes the spending by category and recipient. The bulk of the total is the negotiated PILOT payment the made to the Town of Plymouth, worth $10 million in 2013. With regional purchases estimated at $60 million annually (see preceding section), the sales tax rate of 6.25% would generate $3.75 million in state revenue. Entergy also makes an annual payment to the Massachusetts Emergency Management Agency (MEMA) to support state preparedness for a nuclear energy-related event, in the amount of $2.6 million in 2013. Similar payments totaling $1 million were sent to eight municipalities to offset the costs of local emergency preparedness activities associated with the operation of the plant. This includes all five towns within the EPZ, and three other communities outside the EPZ that provide reception centers if a nuclear event ever required local evacuation from Plymouth.

Table 4.7: State & Local Payments

Plymouth PILOT	$10,000,000		
MA Sales Tax	$3,750,000		
MEMA	$2,600,000		
EPZ Towns	$686,000	$245,000	Plymouth
		$186,000	Marshfield
		$85,000	Kingston
		$85,000	Carver
		$85,000	Duxbury
Non-EPZ Towns	$314,000	$114,000	Bridgewater
		$100,000	Taunton
		$100,000	Braintree
Total	**$17,350,000**		

Sources: Municipal interviews (2014); Author's calculations.

PAYMENT IN LIEU OF TAXES (PILOT)

In the years following the sale of Pilgrim Station to Entergy in 2000, the company paid a relatively small property tax while the previous owner, NSTAR, gradually stepped down its obligations to the Town of Plymouth. Between 2000 and 2006, Entergy paid a modest $9.45 million in property taxes. By comparison, NSTAR paid Plymouth $118.12 million in the same period, under the terms of an agreement reached with the town prior to the sale of the plant.

On April 24, 2007 the town reached a new PILOT (Payment in Lieu of Taxes) agreement with Entergy, netting the town a total of approximately $55 million through fiscal year 2013. Plymouth has continued managing taxes using a PILOT with Entergy. The current PILOT, which expires in 2016, states that Entergy will pay the town $10 Million in FY 2014, $9.5 Million in FY 2015, and $9.25 Million in FY 2016. The PILOT states that "the agreement is a good faith negotiation so that Entergy's payments to the Town each year will be equivalent of the property tax obligations which would otherwise be owed to Plymouth by Entergy based on full and fair cash valuation." The document further states that Entergy will neither sell nor develop any of the forested lands in owns in Plymouth for the duration of the PILOT. However, this clause, along with the rest of the PILOT's terms, is nullified if Entergy files a notice of intent to decommission the plant.

LOCAL EMERGENCY MANAGEMENT

Entergy's municipal payments are not confined to nuclear preparedness activities alone. Instead, recipients are able to allocate the funds where needed. In the aftermath of Hurricane Sandy, for instance, Marshfield used a portion of its funding to meet immediate cleanup needs. Most often, however, the funds are spent on maintenance needs, staff salaries and trainings for volunteers and town personnel, and the purchase of new equipment. Four OCPC towns receive a total of $529,000 in preparedness funding from Entergy: Plymouth, Kingston, Duxbury within the EPZ, and Bridgewater outside of it. On the next page, **Table 4.8** details how three of the OCPC towns allocated their respective funds. Please note that in Kingston and Duxbury, the Emergency Management Department staff is each town's Fire Chief and Deputy Fire Chief, so the payment covers only a portion of their respective salaries. In Plymouth, the Office of Emergency Management's staff is a standalone office, and its payroll is entirely drawn from the Entergy payment.

Table 4.8: Allocation of Pilgrim Station Resources in EPZ Towns, 2014

	Kingston	Duxbury	Plymouth
Salaries & Stipends	**$20,000**	**$47,000**	**$167,000**
Departmental Salary	$8,000	$45,000	$109,000
Personnel Trainings	$12,000	$2,000	$58,000
Maintenance	**$10,000**	**$4,000**	**-**
Equipment & Other	**$55,000**	**$34,000**	**$78,000**
Major Expenditures	Communications: hardware	Communications: software	Communications: hardware
	Laptops	Web/IT services	Internet service
	Flat screen display	Utilities	Web/IT services
	Radio equipment for police cruisers and harbormaster	Internet service	Radiation detection equipment
Other Expenditures	Office supplies	Radio equipment	Staff benefits
	Shelter equipment	Office supplies	Office supplies
TOTAL	**$85,000**	**$85,000**	**$245,000**

Source: Municipal interviews by Practicum students (2014)

STATE EMERGENCY MANAGEMENT

The Massachusetts Emergency Management Agency (MEMA) is the state agency responsible for coordinating federal, state, local, voluntary, and private resources during emergencies and disasters in the Commonwealth of Massachusetts. To be actively prepared for nuclear events, MEMA relies on the Nuclear Preparedness Department (NPD). The NPD is responsible for overseeing planning, training, equipment and exercises to support a radiological emergency response for the Massachusetts population within the EPZ through the Nuclear Safety Preparedness Program (NSPP). The NSPP provides step-by-step guidance to effective communications responses for the communities in the EPZ, as well as the three host communities.

In FY 2014, MEMA's budget was approximately $11 million. Entergy provided $2.6 million, nearly one quarter of the total. The contribution completely underwrote the $442,000 budget of the NSPP, as well as the $298,000 budget of MEMA's Radiological Emergency Response Plan Evaluations (RERPE). The remaining $1.9 million stayed within MEMA for wages, benefits, and operating expenses unrelated to those incurred by the NSPP or the RERPE.

CHARITABLE CONTRIBUTIONS

In 2013, Entergy contributed $297,900 to regional non-profits, civic organizations, and charities in Plymouth and neighboring towns: $247,900 in contributions, and $50,000 in corporate sponsorships. Despite being slightly lower than the average of $350,000 donated in previous years, the funding serves a number of valuable environmental, educational, and elder services in the area.

Financial contributions from Entergy are disbursed through two channels: foundation grants and corporate grants. The Entergy Charitable Foundation (ECF), a 501(c)(3) private non-operating foundation, was established in 2000 to support initiatives addressing income, educational, and literacy issues in areas where Entergy operates. The donations must be itemized with annual IRS filings. As **Table 4.9** shows on the following page, ECF grants awarded in the area totaled $285,969 between 2003 and 2013. In that time, $207,538 was directed towards organizations in Plymouth (such as the town's public school system) or to support an outside organization's initiatives in Plymouth (such as Operation Outreach-USA). Plymouth-directed ECF grants account for 73 percent of the total in Table 4.8.

In recent years, however, the grants have become more widely distributed throughout Plymouth and Barnstable counties. For the five year period from 2009 to 2013, $63,600 in ECF grants reached Plymouth, while $75,000 was distributed to groups in other towns. Slightly under half of the 2009-2013 total has gone to Mass Maritime and the Plymouth Public Library, each of which have received over $30,000 in that time.

Organizations with missions aimed at general community well-being, such as environmental groups, are encouraged to apply for funding through a series of grant programs administered by the corporation itself. These grants have contributed well over $150,000 in the past decade, in addition to the ECF grants detailed above. The Entergy Environmental Stewardship Grant, for instance, provided a total of $76,500 of funding to four non-profits while it was operational between 2003 and 2008: the Friends of Ellisville Island Marsh received at least $30,000; the New England Wildlife Center in Weymouth received $7,000 (in addition to its $22,000 ECF grants); Plimoth Plantation received $10,000 (as well as an ECF grant for $16,100), and the National Marine Life Center in Bourne received $44,500. This is not a complete list, however, as these contributions are not filed with the federal government in publicly available documents.

Table 4.9: Entergy Charitable Foundation Grants, 2003-2013

ECF Grant Recipient	Location	Description	2003-08	2009-13	Total
American National Red Cross	Cambridge	Hurricane Irene relief		$5,000	$5,000
Children's Discovery Museum	Mashpee	Outdoor festival		$1,000	$1,000
Father Bill's & MainSpring	Plymouth	Homelessness in Plymouth		$2,500	$2,500
Habitat for Humanity	Carver	Affordable housing		$2,500	$2,500
March of Dimes	Bourne	Annual fundraiser		$3,000	$3,000
Massachusetts Maritime Academy	Bourne	Tutoring/training programs	$9,500	$35,000	$44,500
New England Wildlife Center	Weymouth	Environmental education	$5,000	$17,000	$22,000
Old Colony YMCA	Brockton	Campaign drive		$10,000	$10,000
Operation Outreach-USA	Holliston	Plymouth literacy programs	$4,000	$9,000	$13,000
Partners Home Care	Plymouth	Maternal and child health		$1,000	$1,000
Plymouth Public Library Corporation	Plymouth	Literacy for Life program	$55,719	$31,600	$87,319
Plymouth Public Schools	Plymouth	Engineering in the classroom	$5,000	$6,000	$11,000
REACH	Plymouth	Silent auction		$1,000	$1,000
Score For A Cure	Hanson	Soccer tournament		$1,500	$1,500
South Shore Community Action Council	Plymouth	Senior hunger prevention		$7,500	$7,500
Whale and Dolphin Conservation Society	Plymouth	Fundraising campaign		$5,000	$5,000
Other Plymouth Recipients	*Plymouth*	*No ECF grants since 2008*	*$51,500*		*$51,500*
Other Non-Plymouth Recipients	*Various*	*No ECF grants since 2008*	*$16,650*		*$16,650*
		ECF Grant Totals	**$147,369**	**$138,600**	**$285,969**

Source: Entergy Charitable Foundation, compiled by Practicum students

4.2 Secondary Operational Impacts

Pilgrim Station also leaves its mark on the regional economy through more indirect means. If Pilgrim Station hires a contractor in the region to install a new security system, this is a direct impact to the region. If the contractor then purchases parts for the job from a supplier in the region, this is an indirect impact to the region: money spent in the region by Pilgrim Station resulted in money spent in the region by the contractor. Similarly, if a contractor in the region is awarded a contract and hires additional workers living in the region to fulfill the terms, the plant has indirectly created additional jobs in the region. Along with this commercial effect on the supply chain, household spending by employees living in the region also creates additional economic output and employment. A workforce

with a substantial payroll and extensive healthcare and pension benefits elevates local demand for health practitioners' offices, banking establishments, restaurants, hospitals, and real estate services.

Economic and Jobs Multipliers

In traditional input/output analysis, Pilgrim Station's direct impacts on the region's economic output, labor income (including payroll, benefits, pensions and other compensation), and employment levels are combined with its secondary impacts on the same components to determine a total impact. Without expenditure data from Entergy, however, it is difficult to estimate how business-to-business transactions might unfold across the region. Furthermore, the inclusion of all $440 million of Pilgrim Station's 2014 direct output can provide a misleading image of the plant's impact. Revenue that immediately leaves the region (in the form of shareholder returns or out-of-state executive compensation, for example) does not have a direct impact on the local economy. While there are limitations to the usefulness of such an approach, particularly in its relevance for the Town of Plymouth, some of the secondary impact levels are worth considering.

To provide a sense of the range, the data in **Table 4.10** on the next page has been culled from economic impact analyses that used IMPLAN, the most common of the several input/output programs used to assess nuclear power plant benefits in recent years. It includes regional-level impact data from three nuclear plants in New England, as well as an estimate for Pilgrim Station based on the other studies. Since input-output analyses occur at the county level, Pilgrim Station's inputs represent only Plymouth and Barnstable counties. Furthermore, since Pilgrim Station's payroll figures do not include benefits and other employee compensation, the number has been increased by 40 percent, the industry standard for benefit estimates. As a result, the labor income of the 495 jobs held by residents of the counties has been increased from $46.5 million (wages only) to $65 million. The result is four secondary impact scenarios.

Table 4.10: Annual Secondary Impact Scenarios for Pilgrim Station

	Secondary Impact Values			
Direct Impact Benchmarks	**VT Yankee** tri-county	**Millstone** single county	**Seabrook** tri-county	**Pilgrim** two county
$1.00 of plant output	$0.23	$0.24	$0.34	$0.24
Pilgrim = $440m output	*101.2m*	*105.6m*	*149.6m*	*105.6m*
$1.00 of labor income	$0.30	$0.62	$0.77	$0.46
Pilgrim = $65m income	*19.5m*	*40.3m*	*50.1m*	*29.9m*
100 plant jobs	122	119	228	119
Pilgrim = 495 jobs	*604*	*589*	*1,129*	*589*
Total Impacts				
Economic Output	$541.2m	$545.6m	$589.6m	$545.6m
Labor Income	$84.5m	$105.3m	$115.1m	$94.9m
Jobs Generated	1,099	1,084	1,624	1,084

Source: Donahue Institute (VT Yankee); Nuclear Energy Institute (all others)

As the table shows, impacts vary based on local conditions and study area size, just as with plant expenditures in Table 4.4, above. The three New England plants share some broad characteristics. The two noteworthy departures are the low level of indirect labor income generated by Vermont Yankee, and the high level of job creation at Seabrook. This are likely explained by the industry mix in the markedly rural Vermont Yankee study area having met fewer of the plant's manufacturing and technical needs when compared to the other plants, and of Seabrook's study area including three counties in the Greater Boston area.

Pilgrim Station functions in an economically diverse county with a variety of manufacturing, service, professional, transportation, and wholesale industries, along with a large utilities sector providing relevant skills and expertise. The regional economy, therefore, is likely able to meet many of the day-to-day needs of both the plant and its locally-settled workforce. Like Millstone, Pilgrim Station is a large economic producer and consumer in a thickly-settled region, and its levels of secondary economic output and jobs created are good estimates for the plant. However, with nearly 1,100 Millstone employees living in the single-county study area, the household spending greatly exceeds what could be expected in the Pilgrim Station study area. As a result, Millstone's remarkably high level of secondary labor income for a single county is likely not applicable to Pilgrim Station. A

value between Millstone and Vermont Yankee is a reasonable approximation, in which every $1.00 of income earned by Pilgrim Station employees in the study area creates an additional $0.46 of labor income.

Therefore, Pilgrim Station's revenues and expenditures in Plymouth and Barnstable counties are estimated to have generated an additional $105.6 million in economic output in 2014. The boost provided by this secondary economic activity created 459 jobs in the county that earned $23.3 million in labor income.

To better illustrate the ways in which secondary impacts the local economy, two special cases are examined: the refueling workforce, and household taxes.

Refueling Workforce

As mentioned above, Pilgrim Station goes offline every other year to replenish the reactor's supply of nuclear fuel. This outage ordinarily begins in April and ends in May, in the "shoulder-season" before the tourism industry in Plymouth and Cape Cod takes off. During the 30-40 days it takes to complete the task, between 700 and 900 contractors join the Pilgrim Station workforce. (The baseline workforce remains active, as the outage provides an opportunity to conduct certain repairs that are otherwise difficult to complete.) Very few of these temporary employees are local, as traveling contractors perform most refueling work. A relatively small share of their earnings enter the local or regional economy, since they work very long hours and bank most of their wages as part of the "peaks and valleys" income that characterizes such contract work.

Completed in the wake of Kewaunee Power Station's closure in 2013, one recent analysis in the Upper Midwest estimated that these transient employees spend approximately $95 per day during the refueling outage: $25 for food, $60 for lodging, $5 for gasoline, and $5 for general merchandise. In New England, Seabrook Station's Site Vice President recently stated that the 1,000 contract workers on hand for the plant's refueling added $4.5 million to the local economy during the project's 30 days, resulting in a per diem of $150 per worker. While these figures were estimates, the difference in per diem spending likely reflects New England's relatively high cost of living.

These per diem values are included in **Table 4.11,** which estimates the total spending by refueling contractors for a given outage at three per diem levels, with "low-high" values for outage duration and workforce size. The totals range from a low of nearly $2 million to a high of $5.4 million. In all cases, the bulk of the spending goes to food and lodging. It is important to note that these numbers represent total spending by the refueling workforce, and make no assertions about where this money is spent. The following paragraph outlines the implications for Plymouth.

Table 4.11: Refueling Workforce Spending

	Duration	Workforce Size	
Per Diem		700 jobs	900 jobs
$95/day (Kewaunee)	30 days	$1,995,000	$2,565,000
	40 days	$2,660,000	$3,420,000
$125/day (mid-range)	30 days	$2,625,000	$3,375,000
	40 days	$3,500,000	$4,500,000
$150/day (Seabrook)	30 days	$3,150,000	$4,050,000
	40 days	$4,200,000	$5,400,000

Source: Deller (Kewaunee); Walsh (Seabrook)

Meals and hotel occupancy are two of Plymouth's sources of excise tax revenue. A meals tax of 0.25 percent went into effect in July of 2014, to finance the cost of a new municipal center and renovate a historic courthouse. The room occupancy tax, which was raised from 4 percent to 6 percent in 2010, supports the town's Tourism Promotion Fund. Since 1996, 45 percent of the room occupancy tax receipts have gone to the fund. Approximating the spending pattern established by the study such that 25 percent of spending goes to meals and 60 percent of spending goes to lodging, and assuming that 30 percent of the refueling workforce's spending will stay in Plymouth during an outage, the municipal receipts from the contractor spending ranges from $22,668 for a 30-day, 700-employee refueling at a low per-diem ($1,122 from meals and $21,546 from lodging), to a high of $61,358 for a 40-day, 900-employee refueling at a high per-diem ($3,038 from meals and $58,320 from lodging).

Residential Tax Revenues

Given the long-term stability of nuclear power plant employment, the relatively high wages, and the advanced workforce age that is common throughout the industry, it is likely that Pilgrim Station's workforce enjoys a high level of home ownership. **Table 4.12** shows the median home values and mill rates from 2015 applied to the residential distribution for ten of the largest municipalities. While not all employees are homeowners, this establishes a useful approximation. For the EPZ towns of Kingston, Carver, and Duxbury, the annual property tax payment of Pilgrim Station employees calculated here is well above the annual EPZ payment from the plant itself.

Table 4.12: Estimated Property Tax Payments by Pilgrim Station Employees, 2015

Town	Workers	Region	Median Home	Employee Real Estate Value	Mill Rate	Annual Payment
Plymouth	190	OCPC	$307,733	$58.47 million	15.54	**$908,580**
Sandwich	40	Cape Cod	$349,500	$13.98 million	14.82	**$207,200**
Kingston	32	OCPC	$329,512	$10.54 million	16.94	**$178,624**
Carver	33	SRPEDD	$259,100	$8.55 million	17.01	**$145,431**
Duxbury	13	OCPC	$609,200	$7.92 million	15.60	**$123,552**
Marshfield	24	MAPC SSC	$386,700	$9.28 million	13.29	**$123,336**
Bourne	25	Cape Cod	$388,779	$9.72 million	10.07	**$97,875**
Barnstable	19	Cape Cod	$457,349	$8.69 million	9.30	**$80,807**
Middleboro	15	SRPEDD	$261,500	$3.92 million	15.78	**$61,890**
Weymouth	15	MAPC SSC	$302,016	$4.53 million	12.90	**$58,440**

Source: Massachusetts Department of Revenue; Author's calculations

The large Pilgrim Station population living in Plymouth results in a significant amount of real estate ownership in Plymouth, nearing $58.5 million. This yields annual residential property taxes in excess of $908,000. This total is augmented by additional annual taxes, such as the motor vehicle excise tax. In 2012, for example, the 55,236 vehicles in Plymouth generated $6.39 million in revenue for the town, for an average of $115.70 per vehicle. Assuming that Plymouth's Pilgrim Station households are two-car families, the motor vehicle taxes that year would have reached $43,966 ($44,948 in 2015 dollars).

In light of the elevated income levels of Pilgrim Station employees relative to Plymouth, the estimates for Plymouth's share of real estate and motor vehicle taxes from plant employees is likely a conservative one. Nevertheless, based on the calculations above, the 2015 total for these two revenue streams is $953,528.

4.3 Closure Impacts

Pilgrim Station's direct and secondary impacts bring a number of socioeconomic benefits to Plymouth and the broader region, in the form of jobs, wages, home ownership, business-to-business spending, household spending, municipal revenues, and support for civic institutions. In the Town of Plymouth, direct impacts from wages, benefits, and municipal payments alone surpassed $35 million. Plant closure would immediately reduce many of these impacts. Employment levels would decline by about half in the year following closure, with further reductions in subsequent years until the plant employed no more than two dozen people after five to seven years: a workforce reduction of over 95 percent. Local expenditures would taper off as well, as fewer components would need inspection, maintenance, or replacement. Donations and other charitable contributions would cease, as would the emergency preparedness payments to the state and individual towns. Finally, the PILOT arrangement Entergy and the Town of Plymouth have regarding Pilgrim Station would be revisited, and likely drawn downward substantially by as much as 90 percent in the first year. Meanwhile, other sources of economic activity in Plymouth and the surrounding towns would begin to slow down as well, as the industries closely tied to the operation of Pilgrim Station adjust to decreased demand, and the households directly or indirectly reliant on Pilgrim Station for income revise their budgets.

Economic Activity and Output

Pilgrim Station directly employs 586 people full-time. Its annual payroll of approximately $55 million provides an average weekly wage that is more than double the average weekly wage in the OCPC region, where approximately half of the workforce lives. Whatever their occupation, nearly all employees at a nuclear plant enjoy a higher rate of pay than similar occupations in other local industries. Those employees with management positions, supervisory responsibilities, or other industry-specific skill sets are likely to look elsewhere for employment at another nuclear power plant, which in all likelihood means moving away from the area. Depending on the occupational composition of Pilgrim Station employees living in Plymouth, this could mean the loss of several dozen families, potentially putting a number of houses on the market in short order. However, employees

performing more general tasks at the plant are less likely to be in-demand elsewhere in the nuclear power industry. For these employees, many of whom are locals, the most feasible option is looking for a similar job in the area. For them, Pilgrim Station's closure represents a loss of future earnings, as the wage premium provided by the plant will be hard to find elsewhere in the region.

Plant expenditures on goods and services in the area, along with discretionary spending from households, is estimated to create more than $105 million in economic activity in Plymouth and Barnstable counties, along with 589 additional jobs in the region that provide $30 million in income. Plant closure would therefore result in the loss of hundreds of well-paying jobs at Pilgrim Station, as well as hundreds more jobs in the area. Industries likely to feel the closure's impacts most directly are in the utilities sector (such as NSTAR and other transmission entities), accommodation and food service industries, banking institutions, real estate agencies, and health care practitioners. In some households, the loss of indirect employment related to the power plant could be the difference between getting by and not making ends meet.

Local Government Revenues

Four OCPC municipalities receive annual financial payments from Pilgrim Station, relating to their interactions with the plant while it is operational. Approximately $10 million goes to Plymouth, nearly all of which is based on the plant's value while it produces electricity. This amount, therefore, would be greatly reduced in the event of the plant's closure. The OCPC towns of Kingston, Duxbury, and Bridgewater each receive over $100,000 per year, as well. (Outside the OCPC, the towns of Carver, Marshfield, Taunton, and Braintree receive annual payments of a similar amount.) These payments would cease with the plant's closure, since the existence of the Emergency Planning Zone is tied to the plant's operation. In many towns, these payments are used to fund in part the salaries of fire chiefs and other vital public employees, as well as to provide equipment upgrades to police and other municipal agencies at no cost to the public.

Local governments may also be affected by plant closure through a decrease in property tax rolls as employees move away to find work outside the area. While some employees would remain in place whether retiring or looking for new work, many would look for opportunities at other power plants within the company or elsewhere in the wider nuclear industry. With closure studies finding that as much as half of the workforce is likely to move away, this could lead to a noticeable drop in the property tax revenues in towns

where annual property taxes paid by Pilgrim Station employees is in the hundreds of thousands of dollars. However, there is not enough research on record to determine with certainty how the process might unfold, and many questions remain about property values and nuclear power plant activities. See **Appendix B** for a local example.

The most significant challenge will be in Plymouth, where the PILOT payment, emergency planning grant, and residential property tax and motor vehicle excise tax revenues from plant employees totaled approximately $11.2 million in 2014. Once the plant is shut down, plant officials are likely to lobby for a reduction in plant valuation on the order of 90 percent. Although the town's ongoing success with the Pinehills residential development has brought new sources of tax revenue to the town, the $10 million in direct payments from the plant is the equivalent of the average tax bill from 2,091 Plymouth single-family residences, more than 10 percent of the town's total.

Non-Profit and Civic Institutions

Regional non-profits, civic organizations, and charities receive approximately $300,000 per year from Pilgrim Station, much of it directed toward environmental, educational, and elder services in Plymouth and neighboring towns. This total does not include in-kind gifts, employee giving, or volunteering. Direct contributions from Entergy would all but cease with Pilgrim Station's closure, and employee giving would decline significantly. While larger institutions will have a more difficult time meeting fundraising goals for special initiatives, most at risk are the smaller entities receiving regular support from Entergy for day-to-day operations. For example, a review of IRS filings reveals that the Friends of Ellisville Marsh has received a total of $154,973 in dues and contributions, and since its founding in 2007. While the $30,000 from Entergy's Environmental Stewardship Grant alone would account for nearly 20 percent of the group's lifetime revenues, a number of other Entergy donations to the group have been acknowledged in newsletters and media reports without making the dollar amounts public.

Land Development

Between 2004 and 2012, one-third of the building permits issued for single family housing in the OCPC were issued in Plymouth, and the number of single homes is now at 18,157. Pilgrim Station is one of the largest private landowners in Plymouth, and its closure could put hundreds of acres of potentially developable land on the market. More than 1,500 of Entergy's 1,700 acres are currently under non-permanent 61A protection, and several of

its parcels zoned for residential use or mixed use are adjacent to medium-to-high density residential development.

While short-term development is not a significant risk, portions of Entergy's land holdings are miles away from the power plant itself. Depending on the levels of radiation detected at various points around the entire property, it is possible that some more remote parcels may have radiation levels low enough to make a partial site release feasible within ten years of plant closure. Two parcels bordering Manomet Village may have significant development potential: one where State Road meets Edison Access Road and Elliot Lane, and the other along White Horse Road by Emerson Park.

In FY 15, Plymouth's total property valuation was 79 percent residential, 9 percent commercial, 9 percent industrial, and 3 percent personal property. Pilgrim Station, zoned light industrial, was valued at $611.3 million, accounting for 74 percent of the total industrial valuation in the town, and a full 32.4 percent of the town's non-residential tax base. In the event of Pilgrim Station's closure, the plant's value will decline significantly, likely to less than one tenth of its pre-closure assessment. Current concerns about the town's balance of tax bases would be further amplified, with the vast majority of the burden falling to the residential properties.

Part Five: Recommendations

Contents and Summary

Given the nature and extent of nuclear plant closure impacts, and the difficulty of mitigating those impacts with traditional approaches to plant closure, planning efforts should be undertaken far in advance of the closure's announcement. This study recommends the following initiatives to the OCPC and the Town of Plymouth, grouped in three interrelated categories:

BUILDING KNOWLEDGE

This category includes recommendations that will enable Plymouth and the OCPC to build their knowledge of plant closure impacts and processes well in advance of the event. Public attention focuses on issues of safety and site reuse, often leaving planning and economic development officials with little time to address the socioeconomic impacts this report has outlined.

BUILDING SUPPORT

Nuclear power plant closure is given scant consideration as a local economic development concern by most policymakers. However, the process of decommissioning a nuclear power plant is inherently a matter of public interest, and Plymouth and the OCPC can take advantage of some growing awareness of plant closure impacts to bring allied groups into the fold and make the best use of potential partnerships.

BUILDING MOMENTUM

Plymouth and the OCPC have an opportunity to take a prominent role in shaping the future of nuclear power plant closure resilience. Local and regional planning provides an opportunity to articulate goals through a public process, secure assistance with technical issues, and define measurable progress towards objectives.

5.1 Building Knowledge

Develop detailed assessments of Pilgrim Station's socioeconomic benefits, to better understand how direct impacts cycle through the region.

High Priority, Near Term: With additional detail on plant expenditures, workforce demographics, and occupational characteristics, Plymouth and the OCPC could pinpoint areas of greatest or least concern. An ongoing survey, undertaken at regular intervals, could help determine how Pilgrim Station's operations support existing businesses,

municipal activities, and non-profit interests. A clearer picture of the impacts will help officials make a stronger case for planning.

Stay abreast of the regulatory and legal considerations that can affect closure timelines, decommissioning strategies, and fuel storage.

Medium Priority, Medium Term: Through the town's Nuclear Matters Committee or other relevant group, Plymouth and the OCPC should become familiar with the ongoing developments in the nuclear energy industry and regulatory sphere. For instance, in 2013 a federal court ruled that the NRC and DOE had acted illegally in shelving the Yucca Mountain repository application process after 2009, and ordered the NRC to resume its review of the DOE's application to establish the nation's long-term waste repository there. On the reactor lifespan side, the DOE has tasked Idaho National Laboratory to research the possibility of extending the lifetime of reactors like Pilgrim Station's beyond the current 60-year licensing period. While these may not have the immediate implications that the ISFSI case currently before the Land Court does, it provides crucial context for understanding and managing public perceptions of risk.

Match existing best practices for major plant closure to Pilgrim Station specifics, to determine goodness-of-fit for nuclear power plant closure.

Lower Priority, Medium Term: With OCPC support, Plymouth should consider reviewing existing best practices for a number of closure types. Energy plants have similar infrastructure, but fewer employees; Manufacturing plants have similar employment, but more workforce redevelopment options; military bases have similar economic impacts, but more robust assistance programs. A broad review will help determine whether a cafeteria approach would be useful, or if an existing approach could be tweaked to fit Pilgrim Station.

5.2 Building Support

Create and maintain a non-adversarial process that keeps parties involved, aware, and focused on socioeconomic impact mitigation.

Highest Priority, Near Term: The OCPC should consider encouraging representatives of Pilgrim Station and NSTAR to participate in any post-operational impact mitigation planning. By starting early, mutually-beneficial objectives can be explored, relevant issues can be considered in a low-pressure environment, and long-term partnerships can

continue to develop. This will likely bring more useful data from the private sector into the planning process for refining the socioeconomic described in this report.

Identify key stakeholders to determine roles and coordinate preparation.

High Priority, Near Term: There are a number of local and regional entities that could provide useful information, assistance, or support if they are made aware of the impacts Pilgrim Station's closure could have on them or their constituents. This report included residential and financial data for the regional planning entities affected by the closure, to help the OCPC make the case for buy-in to these entities. Labor unions are also important stakeholders, as well as potential resources for understanding the plant's workforce in depth. For example, the area's Workforce Investment Boards, such as the South Shore WIB and the Cape & Islands WIB, could be engaged to develop "next phase" workforce retraining options for former power plant employees in the event of closure.

Build relationships with the state and federal agencies that have influence or oversight in the operational and decommissioning processes for nuclear plants.

Medium Priority, Long Term: Because the announcement of plant closure puts intense focus on the topics of safety and site reuse, Plymouth and the OCPC should address the socioeconomic impacts of power plant closure with relevant state agencies in the near future, well before any closure is on the horizon. Dialogue with MEMA and the Department of Public Health will clarify which state agencies are likely to be a part of the decommissioning process, and provide an opportunity to develop a relationship around plant closure instead of decommissioning.

5.3 Building Momentum

Work with state legislators and policy makers to expand the shoulders of state and federal programs for energy transition planning and site redevelopment.

Higher Priority, Near Term: Plymouth may wish to lead a coalition of communities most affected by Pilgrim Station's closure to demonstrate the need for state-level initiatives similar to those established for coal plant closure. These closures have resulted in the establishment of task forces appointed by the governor and the disbursal of millions of dollars to compensate for the reduction of tax revenues. The initiatives responded to a challenging time for an energy industry, and given the recent concerns about nuclear power economics, it is an appropriate time for the state to consider the impacts of nuclear

plant closure. A similar process can also take place at the federal level, where the US Economic Development Administration (EDA) recently launched the Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) Initiative, a multi-agency effort to provide support to communities affected by changes throughout the entire coal economy.

Focus on developing local assets off-site, using regional and town planning initiatives to bring plant and state officials into the process.

Medium Priority, Near Term: In the FY2015 Senate Appropriations Committee bill that established the EDA budget for the year, the Senate directed the EDA to investigate the impacts of nuclear power plant closure. As part of its Comprehensive Economic Development Strategy process (CEDS), the OCPC could incorporate plant closure preparations into its goals for the region, and begin working with other RPAs to take the first steps towards a joint application to the EDA for nuclear plant closure research. Locally, Plymouth may wish to build on the updated Manomet Village Center master plan and the Downtown Village Center master plan, to examine how the village goals identified in those documents may be affected by the closure of Pilgrim Station.

Promote stability in Pilgrim Station-based revenue for municipalities receiving financial support from the plant.

Medium Priority, Long Term: As the state enters into negotiations with Entergy when closure is announced, the OCPC may wish to have a plan in place for the eight communities that receive payments from Pilgrim Station. To ensure that the revenue is not reduced so quickly as to be destabilizing to the public, the OCPC could spearhead an initiative to combine modest municipal savings over the remaining operational life of the plant. At closure, each municipality's final payment from Pilgrim Station would be spread out over two or three years, and supplemented with the community savings to ease transition.

Appendix A: Cleanup Standards

While the NRC has jurisdiction over nuclear power plant decommissioning standards in general, two other federal agencies have jurisdiction over radioactive materials cleanup, as well. The Department of Energy (DOE) is responsible for cleaning up radiological contaminants on its own sites, which include former facilities engaged in materials processing and research and development, among others. The Environmental Protection Agency (EPA) has jurisdiction over those radiological sites that have been listed on the National Priorities List, as part of the Superfund program, with the exception of NRC-regulated facilities. Unfortunately, the three agencies do not agree on a single cleanup standard, and it is the source of much inter-agency tension, as well as public confusion and frustration.

In July of 1997, the NRC issued the "Radiological Criteria for License Termination," which set the threshold for "how clean is clean enough" for reactor decommissioning. The ruling determined that a fully decommissioned power plant could expose an individual to no more than 25 millirem of radiation per year (mrem/yr), if it was to be released to unrestricted use. This represents an absolute cap for an annual dose. With that standard established, the NRC also relies on the ALARA process (As Low as Reasonable Achievable) to determine if the circumstances require more stringent cleanup, to levels below 25 mrem. The NRC, however, is very comfortable with the established limit, and has yet to require a decommissioning facility to move below that level.

Using similar methods, software, and protocols, the DOE also established a 25 mrem/yr dose as its general limit, but in March of 1997 it made a site-specific adjustment to 15 mrem/yr at a site in California's Santa Susana Field Laboratory. Since then, the DOE has stayed with the 15 mrem/yr level, and encouraged the NRC to do the same. The EPA, however, makes assessments based on lifetime risk, not dose. The EPA's goal is to reduce the added risk of developing cancer based on exposure to site radioactivity to one in one million, with an upper limit of one in ten thousand. While the EPA has in the past viewed the risk associated with 15 mrem/yr to be an acceptable level, it has maintained that the dose-based approach taken by the NRC and the DOE is insufficient to ensure the protection of the public. Furthermore, it has (publicly) called for the NRC to ensure that the annual dose incorporated no more than 4 mrem/yr from groundwater radiation.

Unsurprisingly, the federal bickering led a number of states to conclude that they would be better off establishing their own regulations for radiation protection. The first to do so was Maine, which in April of 2000 imposed a 10 mrem/yr dose limit, with a separate 4 mrem/yr dose standard for groundwater. At the time, Maine Yankee was in the process of decommissioning via immediate dismantlement. Officials from the plant estimated that the new regulations would add $25 million to $30 million to the total cost of decommissioning, although this total has not been confirmed. Three more states quickly followed suit. By December 2001, Massachusetts and New York had set standards of 10 mrem/yr, and New Jersey was at the DOE-recommended level of 15 mrem/yr. Unless the regulatory criteria established by the Massachusetts State Department of Health change at some point, Pilgrim Station's decommissioning will need to reach well below the NRC's threshold of 25 mrem/yr before the property could be transferred, which could lead to the site sitting unused for years or decades beyond the 60-year decommissioning timeframe.

Appendix B: Spent Fuel Lawsuits

In 1970, the Atomic Energy Commission (precursor to the NRC) established that the federal government would accept high-level waste generated by nuclear power plants for long-term storage, with the full costs borne by the plant operators. Until an appropriate site was made secure, operators were required to provide shorter-term storage at their own expense, by building and maintaining interim spent fuel storage installations (ISFSIs). A deadline for the long-term storage facility was established under the provisions of the 1982 Nuclear Waste Policy Act, obligating the Department of Energy (DOE) to begin accepting and storing spent nuclear fuel by January 31, 1998.

By that time, all three of the Yankee Companies were in the process of decommissioning their power plants: Yankee Rowe, Connecticut Yankee, and Maine Yankee. The companies filed lawsuits against the United States in 1998, alleging that the DOE breached its contracts with them under the terms of the 1982 Act. The government was found liable in 2006, and in 2012 the three companies were awarded nearly $160 million in damages for spent fuel storage costs incurred between 1998 and 2002. These damages are referred to as Phase I litigation, as a court ruling in 2008 held that the companies must file lawsuits every several years to recover damages. Phase II litigation damages, covering 2003 to 2008, awarded the Yankee Companies an additional $253.4 million, and Phase III damages for costs incurred from 2009 to 2012 are pending. Additional actions are likely to follow until the long-term storage issue is resolved.

In the above case, the fact that the plants are no longer operational means that the total amount of spent fuel being stored is static. A more dynamic issue is before the Massachusetts Land Court, where plaintiffs have alleged that the permitted construction of an ISFSI at Pilgrim Station will diminish their property values. Since coming online in 1972, Pilgrim Station's spent fuel has been stored on-site in a water-filled pool, to keep the fuel rods cool as they undergo radioactive decay. With no off-site option available, the spent fuel pool reaching capacity, and the plant licensed to operate for 27 more years, Entergy must find another location on-site to accommodate additional spent fuel.

In March 2013, Entergy received a permit from the Town of Plymouth's Department of Inspection Services (DIS) for the construction of a concrete pad immediately northwest of the switchyard, to support an ISFSI. The DIS found that spent fuel storage was a "by right" accessory use at Pilgrim Station, and therefore did not require the issuance of a special

permit. This decision was challenged before the Plymouth Zoning Board of Appeals (ZBA), on the grounds that the town's Zoning Bylaws require any facility zoned for Light Industry (such as Pilgrim Station) to obtain a special permit for any accessory uses, and do not allow spent fuel storage casks in such zones. The ZBA upheld Entergy's permit, and 18 residents of Plymouth and Kingston appealed to the Land Court in August 2013.

One year later, Entergy's motion for summary judgment was allowed in part and denied in part, as eleven of the plaintiffs had been able to present evidence that the presence of the ISFSI would diminish their property values. The Court found that affidavits from Williams College Professor of Economics Dr. Stephen Sheppard and University of Chicago Professor Emeritus of Economics Dr. George S. Tolley had reached substantially different conclusions about the ISFSI's impacts on the valuation of properties within two miles of the installation, demonstrating a significant issue of material fact. Pre-trial hearings are ongoing, and the trial is expected to begin in the fall of 2015.

Appendix C: Post Closure Community Snapshots

The two community profiles that follow illustrate two very different experiences of nuclear power plant closure. The host sites share some remarkable similarities: both are small New England towns in rural or semi-rural settings, with a strong shipbuilding heritage. Both hosted low-output single-reactor nuclear power plants from about 1970 to 1996. Twenty years later, the outcomes indicate that neither town was sufficiently prepared for the closure of their respective plants.

Despite their similarities, the towns treated their circumstances as host communities very differently. Wiscasset relied heavily on the plant to provide the revenue for school budgeting, capital improvement projects, and municipal investment. Haddam, on the other hand, relied on the plant primarily to keep taxes low for residents, and to fund the school district. Residents, protective of the town's rural character and small town feel, were happy to keep development pressures out of Haddam. In both cases, the municipalities were leveraging the presence of the plant to accrue some civic benefit, and both attempted to meet challenges head on, through the proactive application of conventional economic development principles.

Most interesting is the manner and outcome of the municipal interventions. In each case, the outcomes have not met expectations. Wiscasset used revenues from the plant to put extensive infrastructure in place during its operation. Once the plant closed, it struggled to keep up with maintenance costs. It partnered with non-profit and regional government groups to acquire former nuclear plant land, and worked to attract outside investment with condition-specific redevelopment expertise. The intent was to create a mixed-use village free from overreliance on a single taxpayer. The developers brought in by Wiscasset were not able to meet their tax obligations, and the development never got off the ground. A local non-profit acquired some of the land recently, removing some developable land from potential property tax rolls. Haddam, which had no compelling infrastructure outside of the nuclear power plant, quickly looked to reuse the plant for another energy production concern, as a smaller (but not insignificant) anchor. With the tax base stabilized, the town could begin investing in the kinds of capital improvement projects they had passed on while the plant was operational. Hopes for a gas-fired electricity plant never materialized, and the site has found no productive reuse. Instead, residential development has increased in the past decade, and Haddam is still without some of the infrastructure that a town looking to expand its commercial/industrial base needs.

The towns described here reacted in timely, productive, and sensible ways. They used the only tools available to municipalities to plan for hosting a nuclear power plant, make best economic use of its presence, and recover from economic impacts of its closing. This emphasizes the complexity of a host community's challenges when a nuclear power plant shuts down permanently, and enters decommissioning. Events move very quickly, options can seem limited, and social, financial, and civic vulnerabilities can be exposed.

C.1 Wiscasset and Maine Yankee

Wiscasset is a small town of 3,700 residents in Maine's Mid-Coastal region, 45 miles northeast of Portland and 24 miles south of Augusta. The town's center lies on the western bank of the tidal Sheepscot River, which flows into the Gulf of Maine at Sheepscot Bay. Wiscasset's downtown is bisected by U.S. Route 1, a major state highway serving Maine's coastal cities and towns. Wiscasset's prosperity as a colonial and early American hub for shipbuilding, seafaring, fishing, ice harvesting, and the timber trade left a number of historic homes in and around the town center. For well over a century, this era was Wiscasset's economic high-water mark.

In 1966, a number of electric utilities serving consumers in all six New England states formed the Maine Yankee Atomic Power Company. The company received a construction permit in October of 1968 to build a nuclear power plant on 820 acres of land south of Old Ferry Road, on a peninsula near Bailey Point. The 860 MW pressurized water reactor began commercial operations at Maine Yankee Nuclear Power Plant in late December of 1972. When Maine Yankee was powered down on December 6, 1996, it was expected that the plant would reopen in August of 1997. During the closure, fuel rods would be replaced, cables would be repaired, and steam generators would be inspected. When the plant's Board of Directors announced in May that it was considering closing the plant permanently, it came as a surprise to employees, contractors, residents, and the town. August did not bring about the resumption of activities at Maine Yankee; instead, on August 6th the board voted to permanently cease operations, and start the decommissioning process (EPRI 2005). The plant had been operational for nearly 25 years, and it had been the town's primary source of revenue the entire time.

Workforce and Population

Prior to shutdown, Maine Yankee's total payroll reached approximately $30 million, with 476 full-time positions and 200 permanent contractor positions, and an average salary of

$54,000 (JSC 1998). The greatest concentration of employees lived in the 20 miles between Wiscasset and Brunswick, most additional staff within an hour's drive. In order to manage the transition, Maine Yankee offered staff a severance and early retirement program, awarding staff who remained on the project until their termination two weeks of pay for every year of service to the plant (EPRI 2005). By the end of 1997, four months after the plant's closure was announced, the workforce was reduced to 317 (JSC 1998). The contractors soon outnumbered the staff, and by 2002 the plant contained approximately 115 employees and 300 contractors (Shadis 2002). After the spent fuel was transferred into dry storage, employment decreased as buildings were demolished. The handful of staff (excluding security) at Maine Yankee is now about two dozen, which will maintain the radioactive waste casks on site until federal issues pertaining to off-site storage are resolved.

Maine Yankee's lifespan paralleled a major period of demographic growth in Wiscasset and Lincoln County. Wiscasset's population grew by 61 percent between 1970 and 2000, from 2,244 to 3,603. Lincoln County's growth in that time slightly outpaced the town's, with a 64 percent change, from 25,692 to 33,616. Both town and county were significantly ahead of the Maine's 29 percent population increase in that time (WCPC 2006). Since the plant's closure, however, the story has shifted. The town grew by just 3.4 percent between 2000 and 2010, to 3,732. This is the lowest rate of decennial growth in Wiscasset since the town's population reached its nadir in 1930. County growth slowed as well, increasing by just 2.5 percent, to 34,457, the lowest rate of decennial growth since the 1950-1960 decade. Meanwhile, state growth outpaced both, rising by 4.2 percent. While modest, this rate outpaced the previous decade's growth (US Census 2010).

Municipal Impacts, Short-Term

The town prospered during the Maine Yankee years, as the plant's tax revenue covered well over 90 percent of the town's budget. Wiscasset provided sewer and utility services to the most rural parts of town at no cost to residents, upgraded the wastewater treatment plant, and expanded cable television availability (Abel 2013). In that time, the town furnished the Fire Department with seven new fire trucks, the Highway Department with six new trucks and plows, and established an emergency services office, with two ambulances. The town built a large community recreation center with an indoor pool and fitness center, and constructed three piers along the river's estuary for recreation and commercial activity (WCPC 2006). The school system admitted students from

neighboring towns for half the allowable cost, and was still able to maintain and upgrade facilities, provide students with field trips, and offer health benefits to staff. At the time of the plant's closing, the town had no debt and a capital reserve of approximately $13 million (JSC 1998).

The financial impact of Maine Yankee's closure was severe and immediate. In 1996, the total property tax collected in Wiscasset was approximately $13.8 million, and $12.8 million of it was paid by Maine Yankee (JSC 1998). In 1998, after the shutdown, the plant's contribution had diminished by more than half, to approximately $5.8 million (Shadis 2002), and the town's total property tax revenue dropped to $8.4 million (WCPC 2006). Although it was impossible to make up the difference entirely, residents and business owners had to dig deeper into their pockets: non-Maine Yankee property tax contributions more than doubled, from $1 million in 1996 to $2.6 million in 1998. The increase was related to utility, school system, public works, and parks and recreation fees that were increased to offset the revenue loss. Neighboring towns sending students to Wiscasset schools saw their bills increase, as well, reaching the maximum cost allowed by the state in 2001 (JSC 1998). School spending decreased, however, as textbooks were updated less frequently, sports programs were abandoned, and teachers were required to take spousal health insurance, if available (Abel 2013).

Municipal Intervention

Although Wiscasset's 1989 Comprehensive Plan had explored the value of broadening the local tax base, the town was not prepared for the sudden shift. In fact, it was not until August of 2000 that the town hired a consultant to provide an economic development strategy for the post-Maine Yankee years. The Business Plan for Economic Development, 2000 was intended as a first step towards Wiscasset's economic stabilization and growth. One of the plan's recommendations was the formation of a public-private partnership to attract outside investment, and in 2002, the Wiscasset Regional Development Corporation (WRDC) was established to facilitate that investment at Maine Yankee. That same year, the Waterfront Master Advisory Committee completed the Waterfront Master Plan, 2002, and in 2003, Wiscasset established a town Office of Economic and Community Development (WCPC 2006). In October 2006, nearly ten years after Maine Yankee powered down for the final time, Wiscasset completed the Comprehensive Plan for the Town of Wiscasset, 2006, reviewing and revising the town's goals, policies, and strategies in light of the town's recent challenges.

As a development corporation, the WRDC brought together the Town of Wiscasset, Lincoln County, and two local non-profit organizations: the Chewonki Foundation, and Coastal Enterprises, Incorporated (CEI). Established in 1915, the Chewonki Foundation is an environmental education organization in Wiscasset that operates a number of summer camps, semester-long academic programs, and outdoor workshops and overnight camping trips. CEI, established in 1977, is a community development organization with a long history of securing grant funding from state and federal agencies for housing and economic development initiatives.

The WRDC successfully secured a federal grant of $1 million to staff their Maine Yankee redevelopment efforts. Encouraged by the WRDC's progress, voters in late 2003 authorized the Town of Wiscasset to spend approximately $2.6 million of bond funding to purchase 431 acres of Maine Yankee property, known as the "Backlands" (WCPC 2006). The bond principal was loaned to a development corporation, which purchased the property to develop an industrial park on a portion of the site. The same developer also took possession of a former generating plant, Mason Station, to develop a mixed-use marina on the waterfront (Moore 2004). Both projects ran into trouble within a few years. The Town foreclosed on the Backlands property in 2010, and has owned it since then. The Mason Station project had been in arrears since 2007, until the Town acquired the land on account of the unpaid taxes in 2012 (Wiscasset 2013).

Wiscasset Today

More than 15 years later, Wiscasset is still a community struggling with the legacy of a prosperous era cut short. Property taxes have risen several times over. One 50-acre parcel, taxed at $289 in 1996, was taxed at $5,000 in 2012 (Abel 2013). While total property values have grown, with a 2013 value of $541 million, it is worth noting that the total property tax paid was $6.95 million, much less than the 1996 amount (Wiscasset Assessor 2013). One reason for this valuation increase is the growth of Wiscasset's tax-exempt holdings. In 2004, the total exemptions accounted for 5.9 percent of the town's $462.5 million valuation. In 2013, that percentage quadrupled, to 23.8 percent (MVRSS 2013). Meanwhile, the value of tax-eligible parcels in Wiscasset has increased by a mere $2.3 million since 2004. This sustained revenue limitation has taken a toll on the town, causing it to restructure its priorities. In late 2013, Wiscasset voters chose to withdraw from the school district, by a more than two-to-one margin.

C.2 Haddam and Connecticut Yankee

Haddam is a small town of 8,346 residents in central Middlesex County, Connecticut, approximately 12 miles upriver from the mouth of the Connecticut River. Straddling the river, it sits about 25 miles southeast of downtown Hartford, 30 miles northeast of downtown New Haven, and adjacent to the mid-sized city of Middletown. A natural cove at Higganum Landing, on the western shore, provided a port for much of the river activity that drove the town's early economy. Ample hydropower flowing down to the Connecticut from the steep hills on the western bank brought several mills to the town, as well, supporting the emerging villages of Higganum, Shailerville, and Tylerville. In the decades between the Revolution and the Civil War, Haddam was a center for shipbuilding and quarrying, before transitioning to a manufacturing economy in the latter half of the 19th century. The town's population declined to approximately 1,750 in 1930, before picking up again in the decades that followed (Haddam Selectmen 1999).

By 1960, Haddam's population stood at 3,466. Although the town was not served by the interstate system, Haddam occupied the midpoint of a 29-mile stretch of State Route 9 that connects Interstate 91 to Interstate 95. In 1965, the Connecticut Yankee Atomic Power Company, a consortium of electric utilities serving customers in all six New England states, purchased 525 acres of land on Haddam Neck, where the Salmon River joins the Connecticut. Construction of a 619 MW pressurized water reactor was completed two years later, and the Connecticut Yankee Haddam Neck Plant (CY) began commercial operations on January 1, 1968. The plant operated on the eastern shore of the Connecticut for nearly 29 years, shutting down on December 4, 1996 (EPRI 2006). That year, Connecticut Yankee accounted for approximately 60 percent of the town's Grand List (DeJesus 1995).

Workforce and Population

With a full-time workforce of approximately 550, Connecticut Yankee had for many years been the largest employer in a small town with limited commercial/industrial activity. The sudden closure of the plant at the end of 1996 affected the town's employment levels significantly. According to the *Haddam Plan of Conservation and Development: 2007 Update*, Haddam's non-farm employment dropped from 1,710 in 1996 to 1,320 in 1997, a 22.8 percent decrease (Haddam Planning 2008). No replacement industry was forthcoming: four years later, in 2001, the employment base stood at 1,400. By the fall of 1999, the decommissioning contractor, Bechtel Power Corporation, assumed

responsibilities for structural demolition. Bechtel's 465 contract employees far exceeded the 150 Connecticut Yankee employees still on site (CDAC 1999). The decommissioning was completed in 2007, and a small number of CY employees will remain until the resolution of federal issues regarding permanent off-site fuel storage.

Haddam's population growth has largely been consistent with county growth levels for much of the past 50 years, and both have outpaced statewide growth in that time. Haddam's boom lasted from 1940 to 1980, as the population grew by more than 25 percent from one decade to the next. The population more than tripled in that time, from 2,069 in 1940 to 6,383 in 1980. This was followed by a pronounced lull, as the town's population grew by no more than 6 percent in each of the next two decades, bringing the 2000 total to 7,157. While growth had also slowed in that period for Middlesex County, the county's growth averaged out to more than 10 percent in the same time period (Haddam Planning 2008). According to the last US Census, however, Haddam has broken out of its slump. The town's population grew by 16.6 percent between 2000 and 2010, far outpacing growth rates of 6.3 percent in Middlesex County, and 4.1 percent statewide.

Municipal Impacts, Short-Term

For Haddam, the most significant impact of Connecticut Yankee's closure was the drop in the tax revenue generated by the plant's value, which would cover the costs of road and bridge repair, and the town's share of the regional school district budget (DeJesus 1995). Further compounding the issue was a legal dispute between the Town and CY pertaining to a town-wide real estate revaluation, completed in 1991. Real estate was revalued every ten years, while personal property and equipment (accounting for much of the plant's value) was revalued annually. At the time, CY accounted for nearly half of Haddam's assessed value, and residents were concerned that the plant's share would drop to one-third of the total, or less (Hamilton 1991).Town officials, plant officials, and property owners all expected the real estate values among Haddam's homeowners to rise significantly as a result of the revaluation, while the plant's value would remain fairly stable.

Instead, the consultant hired by the town to perform the 1991 revaluation increased the plant's share of the tax base, to 57 percent. Although real estate values had risen drastically for residents, the plant's value had increased to $840 million. The plant sought relief in the courts for the assessment, for the years 1991 to 1994. In September of 1996, just three months before the plant announced its permanent shutdown, the state Superior Court

ruled that the fair market value of the plant was $235 million (Marteka 1997). As a result, the town used most of its surplus to pay CY $4.6 million in early 1997, and bonded the remaining $10,000,000 in back taxes owed to the plant (NEAC 1999). The timing could hardly have been worse. In addition to owing the plant a significant sum of money, Haddam's grand list contracted sharply, from nearly $1 billion in 1995 to $565 million in 1997. Haddam was forced to face the uncertainty of a major economic transition with fairly empty pockets, new bond debt, and reduced revenue options.

Haddam's time as a nuclear power plant host community was not marked by extensive public building or infrastructure development. Speaking at the American Nuclear Society's Annual Meeting in 1998, Connecticut State Representative Terry Concannon recalled serving as chair of Haddam's newly-created Long-Range Capital Planning Committee, in 1988. At several public meetings, she encouraged residents to take advantage of the town's major economic engine: "to support the funding of needed projects, such as a fire house, town garage, playing fields, road improvements, and so on... there was much to be done before 2007," in reference to the plant's expected timeline (NEAC 1999). Instead, the town took a different approach: preserving the status quo. According to a 1996 article in The Hartford Courant, "Haddam remained unchanged, for the most part, with its own small country store, postcard-perfect homes, and rural landscapes" (DeJesus 1996). Haddam's property taxes remained very low throughout the Connecticut Yankee years, but did not yield any amenities, like sidewalks, or key infrastructural pieces, like public water and sewer systems (Haddam Planning 2008).

Municipal Intervention

In 1995, Haddam created an Economic Development Commission, to address the town's need for a diversified tax base and commercial composition (MBIA 2000). That year, the commission secured a state grant to hire an architect and a consultant to evaluate village-centered options for diversifying the tax base (DeJesus 1995). With twelve years remaining on Connecticut Yankee's initial operating license, the decision seemed like a prudent example of long-term thinking. By the end of 1996, however, the plant had been shut down, and the town was in a precarious position.

The Economic Development Administration awarded the Town of Haddam an Economic Adjustment Assistance Grant in the fall of 1997. The grant's purpose was to help the town develop an economic strategy addressing the impacts of the plant's closure. In May of 2000, an economic development firm retained with the grant funding presented the

Economic Summary Report: Town of Haddam to the town. The report proposed an economic development plan that included a number of best practices: regional tourism, retail, lodging, incubator space, home business, industrial parks, and office space (MBIA 2000). Notably, the plan proposed spending between $4.5 and $5.9 million to provide public water service to two villages. The plan also suggested that the town encourage the construction of a 750 MW gas-fired electric generator on an existing parking lot at the Connecticut Yankee site, taking advantage of the site's proximity to water and transmission lines. This option had been discussed in general for CY in the past (Hamilton 1991), and had recently returned in a concrete proposal from an outside entity.

In November of 1998, the nearby town of Southington rejected a proposal by AES Corporation, a Virginia-based energy company, to build a 720 MW gas-fired plant in town. After the defeat, and shortly before the Economic Summary Report was released, AES expressed interest in acquiring 20 acres of CY land in Haddam, to build a 750-megawatt gas-fired plant (Libow 2000a). The town hired a consulting firm to assist in evaluating the AES site proposal, which envisioned a $310 million project that would add as much as $200 million to Haddam's tax base, and negotiated a potential tax abatement plan with the company (Libow 2000b). In early 2001, the project took another step forward, as AES and Connecticut Yankee signed an initial agreement for a land sale (CYAPC 2001). By March of the next year, however, the proposal was abandoned, with AES citing security, economic, and supply issues (Libow 2002).

Haddam Today

Since the gas plant proposal fell through, there have been very few concrete proposals for the reuse of CY land. In 2008, Connecticut Yankee hired a redevelopment consultant to advertise 500 acres of the site for reuse, in order to solicit expressions of interest from developers with requisite experience (Overton 2008). Since then, the only change has been the 2013 sale of 38 acres along the Salmon River to the U.S. Fish and Wildlife Service (Marteka 2013). CY continues to be the town's largest single taxpayer, with an assessed value that hovers near $40 million. In 2012, CY paid about $1.2 million in property taxes, or 4.5 percent of the town's $26.6 million budget. Property sales and homebuilding have increased Haddam's population density and housing tax base, but at the expense of the rural character that Connecticut Yankee once supported.

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