

Pilgrim Nuclear Power Station
Plymouth, Massachusetts
Citizen Handbook – Operations - 1972-2019



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PILGRIM NUCLEAR POWER STATION



Pilgrim Station

Owner: Entergy Nuclear Generation Company, LLC. Holtec International LLC. applied to NRC to become Pilgrim's new owner once the reactor ceases operations and is defueled in 2019.

Location: Plymouth, Mass., on shore of Cape Cod Bay

Type: Boiling Water Reactor, General Electric Mark I (same design as Fukushima)

Size: 688 MWE

Cooling Water Source: Cape Cod Bay via once-through-cooling, no cooling tower

Number of Employees:¹ approximately 650 (2018)

Pilgrim was constructed between 1967 and 1972 (its reactor was ordered on August 7, 1965), at a cost of about \$200 million. When Massachusetts deregulated its electric market in 1999, Entergy Nuclear Generation Company bought Pilgrim from Boston Edison for \$14 million plus \$67 million for fuel.²

In June of 1972, the NRC granted Pilgrim a 40 year license to operate until June 8, 2012. Pilgrim began operations on December 9, 1972.

In January of 2006, Entergy filed an application to extend Pilgrim's operating license for 20 years, to June 8, 2032. The NRC granted the extended license on May 12, 2012, despite the fact that a number of still unresolved issues remained pending before the Commission.

Safety Rank: In September 2015 Pilgrim was moved to NRC's lowest safety ranking, joining 2 other Entergy reactors.³ The lowest safety ranking remained until March 2019.

Spent Fuel Pool: The pool is located inside the reactor building on its top floor. It is outside the primary containment. It was originally designed and licensed to hold 880 fuel assemblies. After the federal government banned reprocessing, Pilgrim's license was amended to allow 3,859 assemblies in the pool. As of August of 2017, 2,822 spent fuel assemblies are in the pool.

Dry Cask Storage: Pilgrim currently has one (1) operational ISFSI pad with a capacity of 40 casks administratively limited to 38 casks to facilitate shuffling/cask access. As of spring 2019, the pad has seventeen (17) loaded Holtec System 100 Multi-Purpose Canisters (MPCs) each with 68 fuel assemblies.

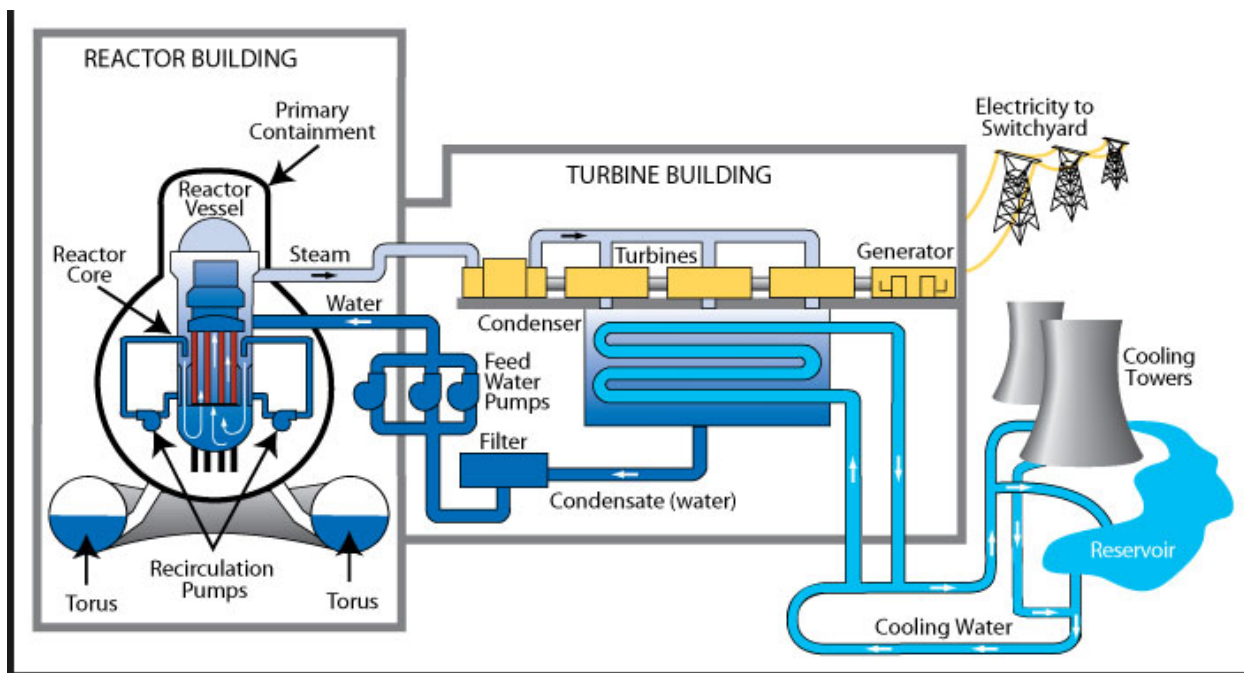
¹ http://www.entergy-nuclear.com/plant_information/pilgrim.aspx

² <http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/Appendices/Nuclear-Power-in-the-USA-Appendix-2-Power-Plant-Purchases/>

³ <http://www.nrc.gov/info-finder/reactors/pilg/special-oversight.html>

A second ISFSI pad is required to store all spent nuclear fuel on-site. The pad will be moved from its present location on the shores of Cape Cod Bay to higher ground, 300 feet from Rocky Hill Road.

Pilgrim: How Boiling Water Reactors Work



Note: Pilgrim does NOT have cooling towers. Cape Cod Bay is the source of its cooling water needed to remove excess heat.

In a typical commercial boiling-water reactor:

- (1) the core inside the reactor vessel creates heat,
- (2) a steam-water mixture is produced when very pure water (reactor coolant) moves upward through the core, absorbing heat,
- (3) the steam-water mixture leaves the top of the core and enters the two stages of moisture separation where water droplets are removed before the steam can enter the steam line,
- (4) the steam line directs the steam to the main turbine, causing it to turn the turbine generator, which produces electricity.
- (5) The unused steam is exhausted into the condenser where it is condensed into water. The resulting water is pumped out of the condenser with a series of pumps, reheated and pumped back to the reactor vessel.

The reactor's core contains fuel assemblies (boiling-water reactors contain between 370-800 fuel assemblies; Pilgrim's contains 580 assemblies) that are cooled by water circulated using electrically powered pumps. These pumps and other operating systems in the plant receive their power from the electrical grid. If offsite power is lost emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators. Other safety systems, such as the containment cooling system, also need electric power.

The Union of Concerned Scientists has posted a simple explanation of how a boiling water reactor works - http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/bwr-intro.pdf

Entergy's Corporate Structure

Entergy is a web of limited liability subsidiary companies, all owned by Entergy Corporation that has its principal office in Louisiana. Like a corporation, a limited liability company or "LLC," is a separate and distinct legal entity. One of the primary advantages of an LLC is that its owners, called members, have "limited liability," meaning that, under most circumstances, they are not personally liable for the debts and liabilities of the LLC.

Pilgrim is owned by one subsidiary, Entergy Nuclear Generation Company. It is operated by another subsidiary, Entergy Nuclear Operations, Inc.

The Massachusetts, New York, and Vermont Attorney Generals attempted to untangle the assets, revenue streams, and obligations between and among these Entergy subsidiary LLCs. Although stonewalled by NRC and Entergy, they could put together the following organization charts.

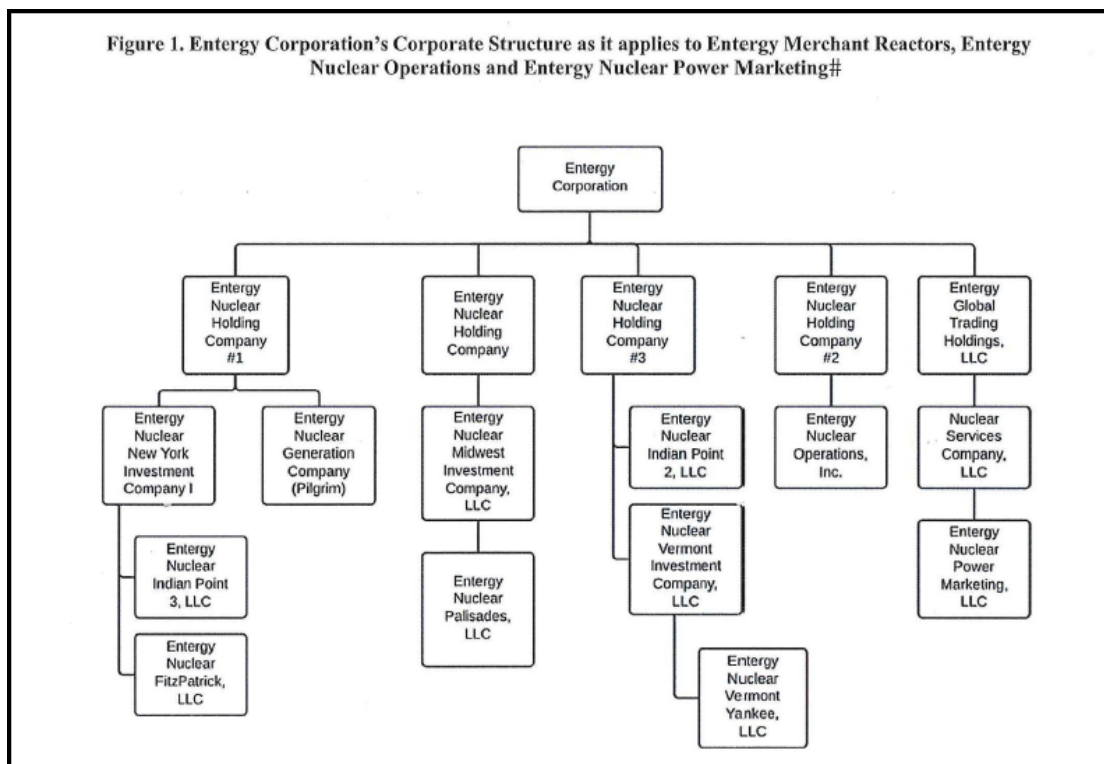
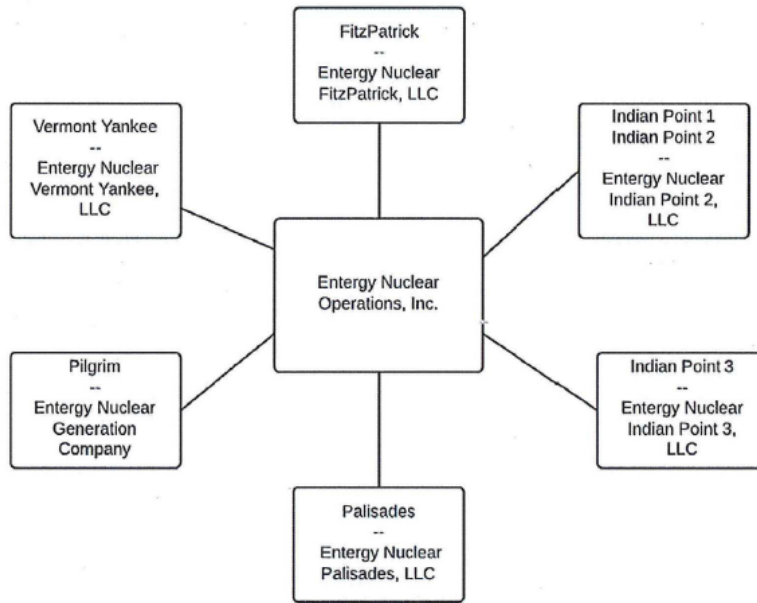


Figure 2. Operation of Entergy's Merchant Reactors by Entergy Nuclear Operations



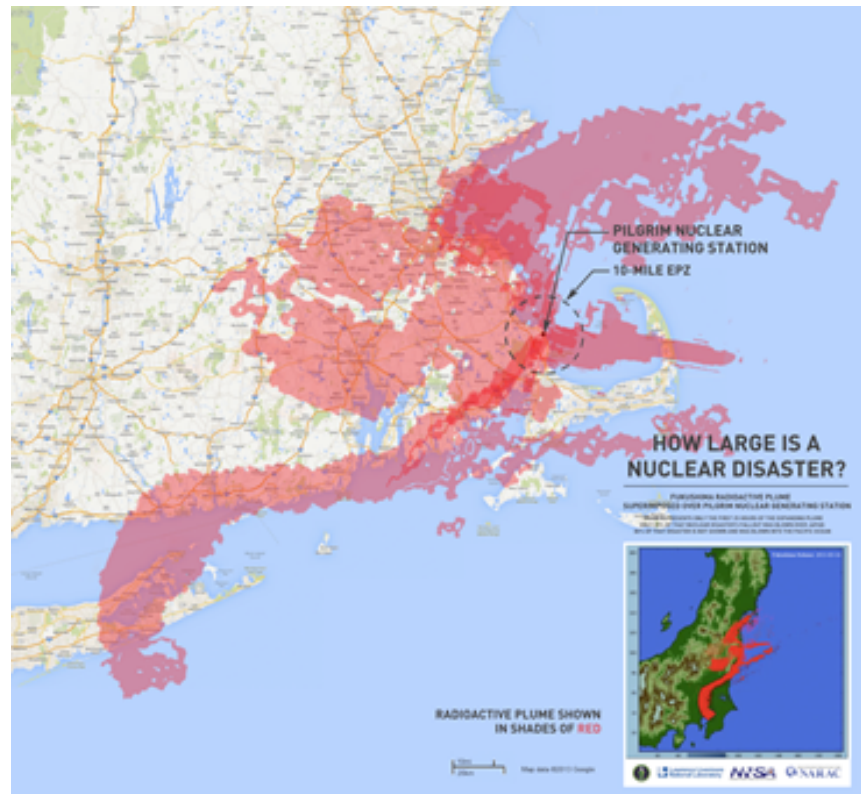
ACCIDENTS

- **What are the potential consequences of an accident?**
- **Entergy's Decision To Close Pilgrim By June 1, 2019 Increases The Probability Of An Accident Today.**
- **Fukushima – Could it happen here?**
- **What are potential causes of an accident:**
 - **Containment Failure-Hydrogen/Steam Explosions**
 - **Spent Fuel Pool Fire**
 - **Transfer of Assemblies from the Spent Fuel Pool into Dry asks.**
 - **Dry Cask Failures**
 - **Lack of and/or Failure of Security**
 - **Inadequate and/or Failure of Critical Electric Power**
 - **Natural Events**
 - **Inadequate Mitigation Strategies**
 - **Age Related Degradation**
 - **Human Error**
 - **Inadequate NRC Oversight**

Consequences of an Accident

When it comes to nuclear reactors, a cost benefit analysis has little meaning. Although the risk of an accident may be small, the consequences can be catastrophic.

Core Melt: The figure below shows Fukushima's first-day plume superimposed over Pilgrim. At Fukushima, subsequent wind shifts spread the plume further afield.



Spent Fuel Pool Fire: The consequences of a spent fuel pool fire are many times worse than those of a core melt; for the simple reason that there is a far greater amount of radioactive material in the pool.

A 2016 study showed that a major spent fuel pool fire could contaminate as much as 100,000 square kilometers of land (38,610 square miles – more than five times the area of Massachusetts) and force the evacuation of millions.

Entergy's Decision To Close Pilgrim By June 1, 2019 Increases The Probability Of An Accident Today - Here is why

Pilgrim is losing money because it cannot compete in New England's competitive electric market with cheaper sources of electricity, namely natural gas and wind. At the same time Pilgrim is 45 years old and requires considerable maintenance. But, because Pilgrim is losing money Entergy has been unwilling to invest in the reactor at the very time Pilgrim needs it. The Nuclear Regulatory Commission has failed to

enforce compliance with its own safety regulations. Entergy's lack of investment in Pilgrim's maintenance and oversight and NRC's past lack of oversight resulted in getting Pilgrim into deeper trouble. Finally, NRC dropped Pilgrim into the lowest safety category and that could cost Entergy about \$100 million, if NRC decides to require the fixes.

What odds do you give that Entergy will decide to make the necessary and very expensive investments in Pilgrim when they are losing money and decided to shut the reactor for good by June 1, 2019 or sooner? What odds do you give that NRC will change its stripes and require real fixes? We do not give very good odds and therefore believe that we are at greater risk of an accident.

NRC Inspection Reports

Entergy is postponing needed maintenance. Entergy has time during refueling reoutages to "clean house." Entergy shut down to refuel in early 2015. The following is a record of problems during 2015.

January: Phase A inspection finds water leak in core spray system that helps cool reactor was known but went unaddressed for nearly a year. Inspectors criticize operators for ongoing failure to follow through with repairs.

February: Reactor lowered to half power after water leak found in main condenser, which holds thousands of tubes to circulate water from Cape Cod Bay to cool turbine. NRC investigation finds a security officer at plant skipped more than 200 assigned fire watches between June 2012 and June 2014.

April: Bearings break down on one of the pumps that draw millions of gallons of seawater from Cape Cod Bay to cool plant systems. Operators knew of problem with bearings since Nov. 7 of the previous year.

May: Rapid power down to 50 percent after shear pins break on traveling screens that prevent seaweed from clogging cooling water system. Wrong pins had been installed during reactor refueling in 2015. The pins had been too small, capable of holding about 3,877 pounds. Correct pins can hold 8,050 pounds.

Phase B inspection finds corroded supports for piping that distributes cooling water to reactor and other plant systems. Finding relates to problem identification and resolution, since corrosion of supports found in October 2015. Some were replaced and repaired; others were not.

A boron panel designed to absorb neutrons and prevent a nuclear reaction called fission from occurring in the fuel pool is found to have deteriorated. Fuel located near the defective panel is moved to another section of pool. Long-standing problem; thinning pool is real solution.

June: Pilgrim operating at 30 percent power crews worked to repair a seawater leak.

July: Electrical relays relied on to shut safety valves that prevent radioactive release during an accident found to have exceeded their shelf life by 12 years.

August: Four-day reactor shutdown after large valve on main isolation valve system fails to close quickly enough during testing. Problem with same valve system caused shutdown in August 2015.

September: Manual reactor scram due to high reactor water level -faulty feedwater regulator valve.

Release of hydrogen gas into the atmosphere above allowable levels. Entergy did not notify the Plymouth or Duxbury Fire Department of the hydrogen release as it is required to do and filed a false report saying that they had followed the notification protocol. A mechanical malfunction of the turning gear that helps spin the turbine and maintain it in proper balance forced a shutdown making eighth day offline.

November: High Pressure Coolant Injection System (HPCI) inoperable (Nov. 7). Six electrical relays that are part of the isolation valve system designed to stop radiation from leaking in an emergency. The relays were meant to be replaced every 10 years. Five were 31 years old and the final one was 17 years old (Nov. 17)

December: Security NRC security inspection found 9 violations of NRC security regulations - 6 identified by NRC, 3 reported by Entergy. (Pilgrim Nuclear Power Station – Security Baseline Inspection Report 05000293/2016403 and Exercise of Enforcement Discretion, Jan. 11, 2017) Spent Fuel Pool Panels: Sixteen more deteriorating panels in spent fuel pool found. They are needed to prevent criticality, (Dec 7) MSIV leaks in three of the eight main steam isolation valves, designed to close to prevent radioactivity from leaking into the environment during a nuclear incident, Dec. 15. Hydrogen leak in excess allowed, Dec. 20.

There was little or no improvement after the 2017 shutdown.

Regulators say performance infractions had potential for safety concern.⁴

“PLYMOUTH — Pilgrim Nuclear Power Station’s performance in the second quarter of this year showed no improvement from previous quarters, based on five violations found by federal regulators that were connected to the staff’s failure to follow procedure and to keep parts in good working order.

⁴ Pilgrim quarterly review finds 5 violations, Cape Cod Times, Christine Legere, August 14, 2017 <http://www.capecodtimes.com/news/20170814/pilgrim-quarterly-review-finds-5-violations>

Although all were classified as “very low safety significance,” the Nuclear Regulatory Commission called them “more than minor” because they had the potential “to lead to a more significant safety concern.”

Many of Entergy’s on-going failures are discussed in an August 22, 2017 article in the *Boston Globe*. <http://www.bostonglobe.com/magazine/2017/08/22/pilgrim-nuclear-plant-due-close-two-years-but-safety-concerns-linger/JB5u9wtKekShHNgHKQ0uxO/story.html>

Recent History

- **2011: Pilgrim had two “near misses”⁵.** A “near miss” raises the risk of damage to the reactor core and thus to the safety of workers and the public.

Reactor and Location	Owner	Highlights
<u>Pilgrim</u> Plymouth, MA	Entergy	SIT: Security problems prompted the NRC to conduct a special inspection. Details of the problems, their causes, and their fixes are not publicly available.
<u>Pilgrim</u> Plymouth, MA	Entergy	SIT: When restarting the reactor after a refueling outage, workers overreacted to indications that the water inside the reactor was heating up too rapidly, and lost control of the reactor. The plant’s safety systems automatically kicked in to shut down the reactor.

- **2012:** Pilgrim re-licensed to operate to 2032
- **2013:** Pilgrim’s performance rating by NRC dropped due to multiple shutdowns and complications placing it among 22 reactors in the country requiring more oversight.
- **2014:** NRC lowers Pilgrim’s performance to degraded and increases oversight. Pilgrim joins 7 other U.S. plants marked “degraded.”
- **2015:** Pilgrim experienced another “near-miss” during winter-storm Juno⁶. NRC keeps Pilgrim’s performance as degraded and increases oversight in April. Pilgrim now joins 5 other U.S. plants marked “degraded.”
- **2015, September:** The Nuclear Regulatory Commission (NRC) downgraded the Pilgrim Nuclear Power Station on September 2, ranking it as one of the three least safe in the country, out of 99. It is one step away from a forced shutdown by the federal regulators. The other two reactors are owned by Entergy also. Pilgrim’s downgrade was based on frequent emergency shutdowns, equipment

⁵ [The NRC and Nuclear Power Plant Safety in 2011: Full Report](#), Living on Borrowed Time, Union Concerned Scientists, pg.,8

⁶ Nuclear Near-Miss at Pilgrim, David Lochbaum, Union Concerned Scientists, May 29, 2015, at <http://allthingsnuclear.org/nuclear-near-miss-at-pilgrim/>

failures, and failure to take corrective actions to address the issues that caused the high number of forced shutdowns⁷.

- **2016, December:** The NRC's Preliminary Inspection Report confirmed what citizens already knew.

Because Pilgrim is on NRC's "watch list" it has undergone special inspections. In December of 2016, the NRC unintentionally "leaked" an email containing NRC report covering the November 28 - December 8 inspection. Written by Donald Jackson, the lead inspector, this report included a long list of flaws at the plant that were observed during the initial week of the inspection. The full report is in the section "NRC Oversight and Risk."

In the email, Donald Jackson, said that:

"The plant seems overwhelmed just trying to run the station."

The list of Pilgrim failures mentioned in the email are:

- failure of plant workers to follow established industry procedures,
- broken equipment that never gets properly fixed,
- lack of required expertise among plant experts,
- failure of some staff to understand their roles and responsibilities, and
- a team of employees who appear to be struggling with keeping the nuclear plant running

Other comments from Jackson include:

- While cooperative, plant operators are "very disjointed in their ability to populate meetings and answer questions. Staffing problems seem to impact how fast the licensee can respond."
- "The engineering group appears unprepared to answer all of the questions being posed by the team." That fact, Jackson said, leads him to question their level of knowledge.
- "The corrective actions in the recovery plan seem to have been hastily developed and implemented, and some have been circumvented as they were deemed too hard to complete.
- We are observing current indications of a safety culture problem that a bunch of talking probably won't fix."
- Recurring problems with the emergency diesel generators at the plant highlight "poor engineering expertise, no communication with the shift manager and poor corrective action."
- **2017:** The NRC completed its special inspection. The NRC decided to keep Pilgrim in its lowest safety category, category 4.
- **2019: Pilgrim was promoted by the NRC and taken out of Category 4.** On the one hand, it seems clear NRC's oversight improved performance at Pilgrim. On the other hand, the promotion could be part of the NRC Commissioner's announcement that they will consider changing the Annual Oversight Process and allow the licensees to largely judge themselves- self regulate. This plan will

⁷<http://www.nrc.gov/info-finder/reactors/pilg/special-oversight.html>

look more rationale, although it is not, if the reactors across the nation score high on the Annual Assessments.



The NRC's Accident Sequence Precursors Report Pilgrim is the Leader of the Pack

The NRC defines an accident sequence precursor (ASP) as “an observed event and/or condition at a plant, when combined with one or more postulated events (e.g., equipment failures, human errors), could result in core damage.” <http://allthingsnuclear.org/dlochbaum/accident-sequence-precursors-for-nuclear-reactors>. The following NRC chart shows the number of accident precursor events that have occurred at different nuclear reactors. For a nuclear reactor, this is the Dean's “Other” List. The farther you are down the list, the better you are doing. But Pilgrim is at the top, over time it has had 23 ASP events, more than any other reactor.

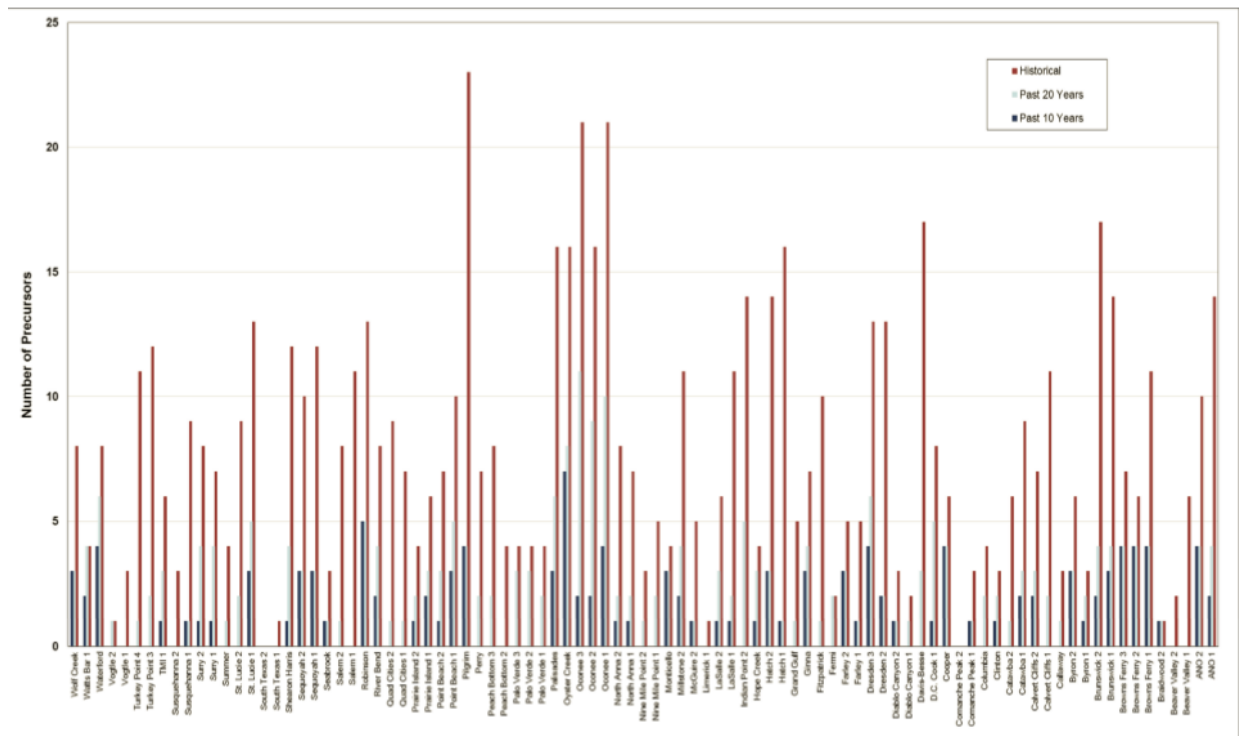


Figure 11. Precursor Counts by Plant.

What Are The Principle Risks That We See?

- Fukushima can happen here.
- The required mitigation strategies put into place to address lessons learned from Fukushima are either inadequate, not yet implemented, or indefinitely postponed by the NRC.
- Pilgrim, a sister reactor to Fukushima, is a flawed design. Its containment is too small and in certain accident scenarios it can explode like Fukushima's Unit 1,2, and 3.
- Pilgrim's spent fuel pool is subject to a catastrophic spent fuel fire because the fuel is too tightly packed into its overcrowded pool located outside primary containment, with a thin roof overhead.
- Pilgrim is vulnerable to a terrorist event.
- Pilgrim's safety systems depend on outside electric power to operate. Electric reliability is not assured.
- Pilgrim is subject to extreme natural events –flooding, earthquakes and severe storms.
- Pilgrim is an old reactor subject to age related degradation.
- NRC oversight policy is inadequate.
- Last, human error cannot be discounted.

FUKUSHIMA COULD HAPPEN HERE

*Pilgrim is the same design as the Fukushima reactors and shares its flaws.
 "Although we have had a string of good days, all it takes is one very bad day."*

Fukushima: the Story of a Nuclear Disaster by David Lochbaum, Edwin Lyman, Susan Q. Stranahan and the Union of Concerned Scientists, 2014⁸ concluded that,

A Fukushima-type nuclear disaster could happen in the U.S. Fukushima wasn't a "Japanese" nuclear accident—it was a nuclear accident that happened to occur in Japan. In fact, if exposed to similarly complex challenges, *all 100 operating reactors in the United States* would likely have similar outcomes. Worse, Japanese and U.S. regulators share a mindset that severe, supposedly "low probability" accidents are unlikely and not worth the cost and time to protect against. Fukushima showed that unlikely events *do* occur.

Nuclear power can be safer—but U.S. regulators aren't doing their job: Despite a long history of complacency and underestimating risks, the U.S. agency charged with nuclear power—the Nuclear Regulatory Commission (NRC)—could heed the lessons of Fukushima and improve U.S nuclear safety. Unfortunately, the NRC hasn't learned Fukushima's lessons—and U.S. nuclear power plants aren't as safe as they could and should be.

Lessons Learned, Or Not Learned, From Fukushima

On March 11, 2011, a 9.0-magnitude earthquake struck Japan and was followed by a 45-foot tsunami, resulting in extensive damage to the nuclear power reactors at the Fukushima Dai-ichi facility. What lessons have been learned and what is the status of implementation? The NRC's plant status implementation of mitigation strategies ordered by NRC are available on NRC's website. (<http://www.nrc.gov/reactors/operating/ops-experience/japan/plants/pilg.html>)

ORDER	COMPLETION DATE	STATUS
Order for Mitigation Strategies to Respond to Extreme Natural Events Resulting in the Loss of Power at Plants (EA-12-049)	Complete full implementation no later than two (2) refueling cycles - 8 after submittal of the overall integrated plan, as required in Condition C.1.a, or December 31,2016, whichever comes first. December 2015	Complied The OIP for EA-12-049 was submitted (Reference 3) on February 28, 2013. On May 20, 2015, PNPS entered Mode 2 (startup) following refueling outage 20 which was two refuel cycles after submittal of the OIPs. Full compliance with Order EA-12-049 was achieved at that time.

⁸ http://www.ucsusa.org/nuclear_power/nuclear_power_risk/safety/fukushima-book.html

Modified Order for Ensuring Reliable Hardened Containment Vents EA-13-109)	Phase 1, severe accident capable wetwell vent: Startup following Spring 2017 refueling outage Phase 2, drywell severe accident capable drywell venting system: June 30, 2019	Entergy applied to postpone implementation until after plant closure. NRC allowed Pilgrim to postpone implementation until AFTER it shutdown; then it would apply for relief from the Order (April 17, 2017).
Order for Enhancing Spent Fuel Pool Instrumentation	December 31, 2016	Complied July 17, 2015
Requests for Information		
Request for Information for Seismic and Flooding Reevaluations and Walkdowns,		Entergy requested deferral of actions related to flooding and seismic reevaluations for Pilgrim in anticipation of the planned permanent shutdown of Pilgrim in mid-2019. NRC concurred, April 17, 2017.

National Academy of Sciences (NAS), July 24, 2014, released the final pre-publication report by a committee tasked with reviewing the March 2011 accident at the Fukushima nuclear plant in Japan and its lessons for improving the safety of U.S. reactors. Initial comments on the report from the Union of Concerned Scientists are available at: <http://allthingsnuclear.org/nas-report-lessons-learned-from-fukushima-nuclear-accident-for-safety-of-u-s-nuclear-plants/>

POTENTIAL CAUSES OF AN ACCIDENT

What can go wrong? The Union of Concerned Scientists says that “Nuclear power plants are complex systems operated by human beings who can and do make mistakes. As such, they are vulnerable to accidents and failures because of natural disasters such as flooding, earthquakes and extreme weather, fires, equipment failures, improper maintenance, and human error.”⁹ Add to the list, terrorism or acts of malice.

The major risks of an accident at Pilgrim Station include: a fundamental design flaw leading to containment failure; spent fuel storage risks; security, loss of electric power to operate safety systems; natural events (storms, flooding, seismic) coupled with inadequate Post Fukushima mitigation (FLEX) strategies; age related degradation of components and improper maintenance; NRC failing to enforce its own rules, and human error.

In the event of an accident, emergency response plans and procedures and post accident cleanup planning come into play. They also are inadequate.

⁹ <http://www.ucsusa.org/our-work/nuclear-power/nuclear-power-accidents#.VOtZyHzF-sw>

CONTAINMENT FAILURE

VENT & HYDROGEN/STEAM EXPLOSIONS

The risk of a containment failure is inherent in Pilgrim's design Pilgrim's containment, like that of all GE Mark I Boiling-Water Reactors, is too small.

More than forty years ago, the NRC identified a serious design flaw in GE Mark I Boiling-Water Reactors (BWRs) - the containment is too small so that in certain accident scenarios the containment would fail in the event of pressure build up- hydrogen and/or steam.



The lack of containment integrity of the GE Mark I reactor design was recognized as early as 1972. Dr. Stephen Hanauer, an Atomic Energy Commission safety official recommended that the Mark 1 pressure suppression system be discontinued, and any further designs not be accepted for construction permits. Hanauer's boss, Joseph Hendrie (later an NRC Commissioner) essentially agreed with Hanauer but denied the recommendation because it could mean the end the nuclear power industry in the U.S.¹⁰ An NRC analysis of the potential failure of the Mark I under accident conditions concluded in a 1985 report that, "Mark I failure within the first few hours following core melt would appear rather likely." In 1986, Harold Denton, then the NRC's top safety official, told an industry trade group that, "The Mark I containment, especially being smaller with lower design pressure, despite the suppression pool, if you look at the WASH-1400 safety study, you'll find something like a 90% probability of that containment failing."¹¹

Fukushima demonstrated in real-time that these fears were true – Fukushima units 1, 2, and 3 exploded. Pilgrim and the failed Fukushima reactors have the same design.

Direct Torus Vent (DTV) - Not a Full Proof Fix

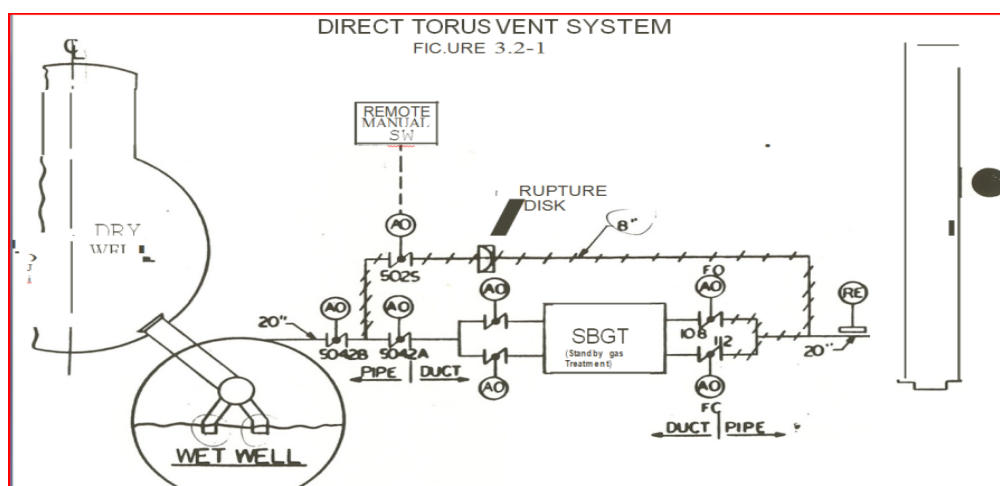
Pilgrim's Direct Torus Vent- neither passive, filtered, nor severe accident capable

¹⁰ Copies of the three original AEC memos, including Hendrie's, November 11, 1971: outlines problems with the design and pressure suppression system containment; September 20, 1972 : [memo from Steven Hanauer recommends that U.S. stop licensing reactors using pressure suppression system](#); September 25, 1972: [memo from Joseph Hendrie \(top safety official at AEC\) agrees with recommendation but rejects it saying it "could well mean the end of nuclear power..."](#) See EA-12-050 Adjudication Proceeding <http://adams.nrc.gov/ehd/> All Power reactors EA-12-050 & EA-12-051, Pilgrim Watch Pleading, Exhibit 3

¹¹ "Reactor design in Japan has long been questioned," NYT, March 15, 2011, Tom Zeller referencing "Denton Urges UNRC to Settle Doubts About Mark I Containment," Inside NRC, McGraw-Hill, Vol. 8, No. 12, June 9, 1986.

To protect the Mark I containment from a likely total rupture, NRC advised venting high pressure build-up. As a result, an industry workgroup designed and installed a "direct torus vent system" at all Mark I reactors, beginning with Pilgrim. However the NRC recognized that the vent was not full-proof. During some ATWS (anticipated transient without scram) events, the pressure in the containment will rapidly increase. Venting pressure could be reached in a matter of minutes rather than hours. Therefore venting may not prevent containment failure because of the high containment pressurization rate but the NRC apparently decided it would nonetheless provide additional time to shut down the reactor and delay a core melt.¹²

Operated from the control room, the DTV is a reinforced pipe installed in the torus and designed to release radioactive high-pressure steam generated in a severe accident by allowing unfiltered radioactive release directly to the atmosphere through the vent stack. Reactor operators have the option whether to open the vent to, what was believed pre-Fukushima, "save the containment," or when to keep it closed in order not to unnecessarily expose the public and the environment to unknown amounts of harmful radiation.



Pilgrim's Direct Torus Vent (DTV) System

Post Fukushima Vent Orders ¹³

NRC excused Pilgrim from complying with NRC's Vent Order

On March 12, 2012, after the Fukushima disaster, the NRC issued an Order (EA-13-109) requiring all U.S. nuclear power plants with the Fukushima-style containment design to install a severe accident capable, reliable, hardened vent to remove heat and pressure before potential damage to a reactor core occurs in order to prevent an explosion and also help delay reactor core damage or melting. After issuing the

¹² Chairman Kenneth M. Carr, Responses to Concerns raised by W.R. Griffin, June 21, 1990, Enclosure 2, Response to Question 2, page 5. See EA-12-050, Adjudication Proceeding <http://adams.nrc.gov/ehd/> All Power reactors EA-12-050 & EA-12-051, Pilgrim Watch Pleading, Exh.,5

¹³ NRC Electronic Library, ADAMS, Accession No. ML15043A754; <http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/hardened-vents.html>

order, additional NRC evaluations examined the benefits of venting *after* reactor core damage occurs. In June 2013, the NRC modified the Order to ensure those vents will remain functional in the likely conditions following reactor core damage.

The order on venting requires licensees to implement its requirements in two phases. In Phase 1: Licensees of Boiling Water Reactors with Mark I and Mark II containments were required to design and install a “hardened” venting system that provides venting capability from the wetwell during severe accident conditions. These conditions include seismic, snow, ice, extreme high or cold temperatures. They do not include flooding. (See section below on Natural Events) Pilgrim was initially required by the Order to implement Phase 1 in Spring 2017.

However on June 24, 2016, Entergy made a request to NRC to extend compliance with the Order until after Pilgrim closed on June 1, 2019; and said that Pilgrim then would ask relief from the Order. Pilgrim Watch (PW) filed a Request for Hearing September 7, 2016 challenging Entergy’s request; the proceeding is available on NRC’s Electronic Hearing Docket, folder Pilgrim 50-293-EA. The PW Petition argued that Entergy’s request should be denied because: (1) It would deny citizens and communities the protection a reliable severe accident capable wetwell venting system would provide during the two remaining years of Pilgrim’s operations. (2) Its argument in support of its request to NRC did not hold water. (3) Further, it should be denied on procedural grounds. It is in reality a request for a license amendment; and Entergy should be required to follow NRC’s rules and practices for amending its license that includes an opportunity for hearing. Also, Entergy’s request was not made in time.

Once again Entergy showed that it is more than willing to shortchange public safety in order to save money. **The NRC concurred. On April 17, 2017, the NRC decided not to enforce its own rules and require Pilgrim’s wetwell vent to be severe accident capable.**

In Phase 2, Licensees were required to design and install a venting system that provides venting capability from the drywell under severe accident conditions, or, alternatively, to develop and implement available containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions.

The later provision let the industry off the hook. Pilgrim originally said it would implement Phase 2 in Spring 2019 – 10 years after Fukushima; but with its closure June 2019, it will not do so.

Pilgrim’s Wetwell Vent Installed in the late 1980’s

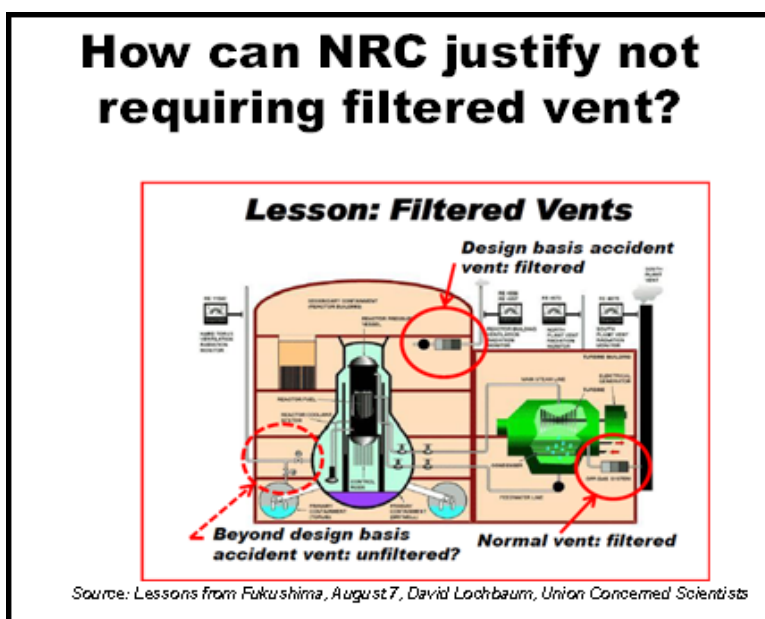
DTV Not Passive: Because of GE’s design deficiency, the original design for a passive containment system was compromised in favor of a system that relied entirely on human control, despite all the associated risks of error and technical failure. A rupture disc at the beginning of the vent (not end as in the present design) would solve that problem. Also, the design could be adjusted to allow venting at a lower pressure by adding some piping to allow by-passing the rupture disc.

DTV Not Filtered: The NRC’s decision further compromised the design by not requiring a filter on the vent. After NRC studied lessons learned from Fukushima (2012), the NRC Technical Staff recommended that the NRC Commissioners require filters (SECY-12-0157). The staff argued that absence of a filter not only contaminates offsite communities but also had significant negative unintended consequences at Fukushima. The New York Times explained that “Government officials have also suggested that one of the primary causes of the [Fukushima] explosions was a several-hour delay in a decision to use the vents,

as Tokyo Electric managers agonized over whether to resort to emergency measures that would allow a substantial amount of radioactive materials to escape into the air¹⁴.”

NRC Commissioners first voted not to require filters in the DTV; they then kicked the can down the road “for further study.” They ignored the facts that filters are required for normal everyday gaseous release from reactors. The NRC has given no reason that design-basis gaseous releases are filtered; yet much larger gaseous releases during severe accident are unfiltered. Sweden, France, Germany, Romania and soon Japan all require filters¹⁵ - but not the United States. Another NRC political decision to save the industry money.

After the Commissioners rejected its initial recommendations, the NRC staff re-studied filtering, and renamed it “Containment Protection and Release Reduction Rulemaking.” In its renamed study, **the Staff backed away from its earlier recommendation to require filters on vents**¹⁶. The NRC Commission supported the Staff’s revised recommendation – no filters. Also the NRC Commission, August 19, 2015 voted not to issue a Federal Register Notice requesting public comment on the Staff Draft recommendation but instead to move forward without public comment. (Commission Notation Vote, Decision item SECY-15-0085)



Staff’s 2015 Recommendation - No Filters Required:

To justify its reversal of its earlier recommendation, the Staff changed the the way it performed its cost benefit analysis. In its renamed study, the Staff relied on flawed and unsupported assumptions; and used outdated consequence codes- MELCOR, MACCS, and SOARCA.

¹⁴ [*Hidden Dangers: Japanese Officials Ignored or Concealed Dangers*](#), NYT, Hiroko Tabuchi reported from Tokyo, Keith Bradsher from Hong Kong, and Matthew L. Wald from Washington, May 17, 2011.Exh., 7

¹⁵ NRC Staff’s Post-Fukushima Trip report to learn about other country’s DTVs with filters and rupture discs to better advise the NRC Commissioners on what to do here to reduce risk is now publicly available and can be found at NRC’s Electronic Library ADAMS, Accession number **ML12178A670**

¹⁶ Draft Regulatory Basis for Containment Protection and Release Reduction for Mark I and Mark II Boiling Water Reactors (10 CFR Part 50), May 2015 (ADAMS Accession No. ML15022A214)

Economic consequences also were given a backseat because they showed an estimated **\$11 to \$64 million** dollar filter would save **\$3.51 billion** dollars in offsite economic consequences. (Table 4-2, Staff analysis) Health consequences were limited to fatal cancers and in a too-small geographic area. Health consequences were determined to be zero by making the ludicrous assumptions that (i) evacuations would take less than 6 hours meaning everyone would get out of “Dodge” in time; and (ii) accidents would be slow breaking because severe accident water addition (SAWA) measures at reactors would work 60% of the time and slow the need to vent until folks got away. The staff conveniently ignored the 40% of the time SAWA was estimated not to work.

Industry- No Excuse Not to Install a Wet Well Filter

The Wetwell’s “Scrubbing” Capability provides no excuse not to filter.

A U.S. government report from 1988 entitled “Filtered venting considerations in the United States¹⁷” said:

“Within the United States, the only commercial reactors approved to vent during severe accidents are boiling water reactors having water suppression pools. The pool serves to scrub and retain radionuclides. The degree of effectiveness has generated some debate within the technical community. The decontamination factor (DF) associated with suppression pool scrubbing can range anywhere from one (no scrubbing) to well over 1000 (99.9 % effective). This wide band is a function of the accident scenario and composition of the fission products, the pathway to the pool (through spargers, downcomers, etc.), and the conditions in the pool itself. Conservative **DF values of five for scrubbing in MARK I suppression pools, and 10 for MARK II and MARK III suppression pools have recently been proposed for licensing review purposes. These factors, of course, exclude considerations of noble gases, which would not be retained in the pool.**” (Emphasis added)

The decontamination factor of 5 for the Mark I containment (as used in units 1 through 5 of Fukushima Daiichi and the 23 in the U.S. including Pilgrim) means that 80% of the radioactive substances (excluding noble gases) is retained, while 20% is released. The FILTRA system installed at 10 Swedish nuclear power plants and one in Switzerland is designed to ensure that in a severe accident 99.9% of core inventory is retained in the containment or the filters.

The difference between releasing up to 20% versus 0.1% is huge. *It means that up to 200 times more radioactivity is released in the system* defended by TEPCO and used by all U.S. BWR Mark I operators (including Entergy) versus the enhanced system used in Europe and commercially available worldwide.

Backpressure also provides no excuse not to filter.

¹⁷ Filtered Venting Considerations in the United States, R. Jack Oallman, L.G. (Jerry) Human, John (Jack) Kudrick:: <http://www.osti.gov/energycitations/purl.cover.jsp?purl=/6945722-maXGrD/6945722.pdf>

Industry has argued that filters would be dangerous due to backpressure. Again, not so. Their argument is about saving money, not safety. Backpressure is not an obstacle. Backpressure is an issue that is repeatedly faced at nuclear reactors, and successfully managed. It is true that installing filters in the torus vent lines will cause higher pressure inside containment than if no filters were present; but, this is not a “show-stopper.” Currently, operators are instructed to open the torus vents when containment pressure reaches so many pounds per square inch (psi). At (x) psi, the opened torus vents keeps the containment pressure below the level that could cause it to catastrophically fail. When the properly designed filters are installed in the torus vent lines, the procedures may need to be revised to guide the operators to open the vent valves at a pressure, (y) psi, that is slightly below (x) psi to accommodate the backpressure from the filters; but that is all.. With a properly designed filter, the pressure reduction - if any - will be negligibly small.

Therefore, the only reason that a wet well vent filter could not be installed in the torus vent line is incompetence (are capable engineers really unavailable) or cheapness (the industry does not want to pay for capable engineer or their designs) We expect that Entergy has, or can readily find, the skill set to design such a filter system. We simply need the spine to make it happen; we trust NRC will have the spine after Fukushima.

NRC Determined Dry Well Vent Also Needed (EA-13-109; revised EA 12-050)

Pilgrim’s probability of explosion is increased because it lacks a dry well vent

On June 6, 2013, the NRC issued a another order (EA-13-109), this time requiring installation of a second vent, a dry well vent, because the wetwell vent (ordered by the Commission in its earlier EA-12-050) would be inoperable in a severe accident with core melt. In its new order, the NRC said that:

During severe accidents involving molten core debris breaching the reactor vessel, mitigating strategies include injecting water into the containment to help prevent drywell liner melt-through, which **would result** in a release pathway directly into the reactor building. However, *water injection can eventually increase the water level in the suppression pool to a point where venting from the wetwell would no longer be possible. Without venting containment pressure could continue to increase, threatening containment failure.*” (EA-13-109, 7; Emphasis added)

Inexplicably, unless the only reason is not to require reactor operators to spend the money to do what safety requires, EA-13-109 did not require operators to fix the identified safety issues until more than six years after the order was issued, June 30, 2019.¹⁸

¹⁸ EA-12-050, modified by EA-13-109, does not have to be implemented until “startup from the second refueling outage that begins after June 30, 2014 or June 30, 2018, whichever comes first.” (Order, 11); EA—13-109 ‘Phase-2 drywell vent system or’ development of a reliable containment venting system strategy that makes it *unlikely* that a licensee would need to vent from the containment drywell during severe accident conditions” (Order, 9, emphasis added) is “no later than startup from the first refueling outage that begins after June 30, 2017, or June 30, 2019.

Our view is that the NRC cannot pretend to satisfy its AEA obligation to protect the public health and safety now by allowing Pilgrim, and logically by extension reactors of like design, to continue to operate until EA-12-050 provisions, as revised by EA-13-109 are fully implement close down sometime.

Reality not Theory - Lessons from Fukushima

Pilgrim assumes that the DTV would work without filters; that theoretical assumption was the underpinning of its assumed probabilities in accident sequences. But this supposed lack-of-need was “shown” only by theoretical analysis.

There have been only real tests of the DTV – Unit 1, Unit 2, and Unit 3 at Fukushima, March 2011. In each test, the containment. Three out of three failures are not a good score. The real reasons for these failures of Fukushima’s unfiltered DTV to prevent containment failure include:

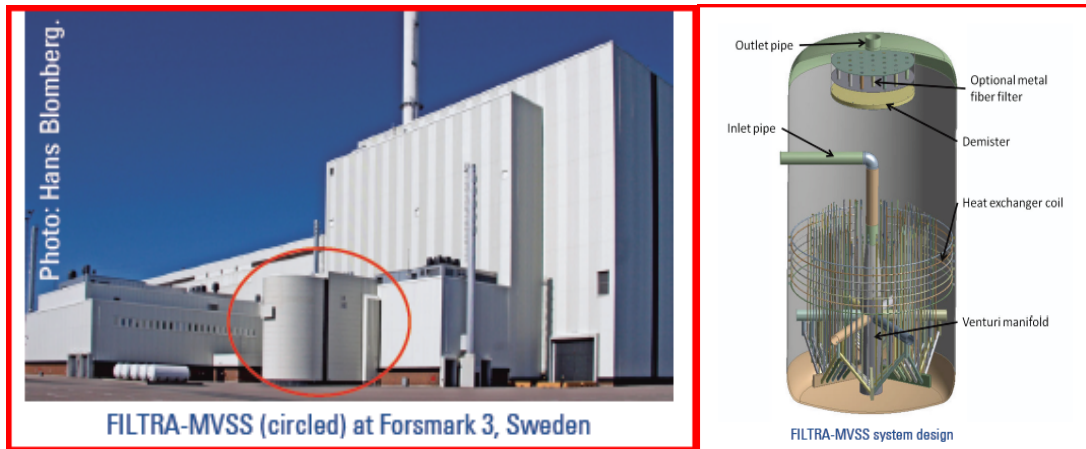
- a) Human Error - Properly trained operators decided not to open the DTV when they should have because they feared the effects offsite of significant unfiltered releases.
- b) Vent failure - When the operators finally decided to open the DTV, they were unable to do so.
- c) Containment failure - The failure of the DTV to vent led to the expected containment failure/explosions that resulted in significant ongoing offsite consequences.

While Japan is installing filtered vents in its reactors joining other nations around the world, the U.S remains an outlier-saving industry money not public health.

Designs that Reduce Risk Are Available Today

There a number of systems, available now, that will reduce the risk of Pilgrim’s containment failing. For example, the Westinghouse FILTRA-MVSS (multi-venturi scrubber system) shown below a passive, self-regulating system that provides filtered pressure relief of BWR/PWR reactor containments.¹⁹ The system is passively actuated by a rupture disc; no electric power is required. It can provide relief in the event of a total loss of AC power for 24 hours that otherwise would lead to the loss of core cooling ability. This includes a total loss of electrical power from both the external grid and all plant-specific power back-up systems, as well as loss of steam turbine-driven core cooling pumps.

¹⁹ http://www.westinghousenuclear.com/Products_&_Services/docs/flysheets/NS-ES-0207.pdf



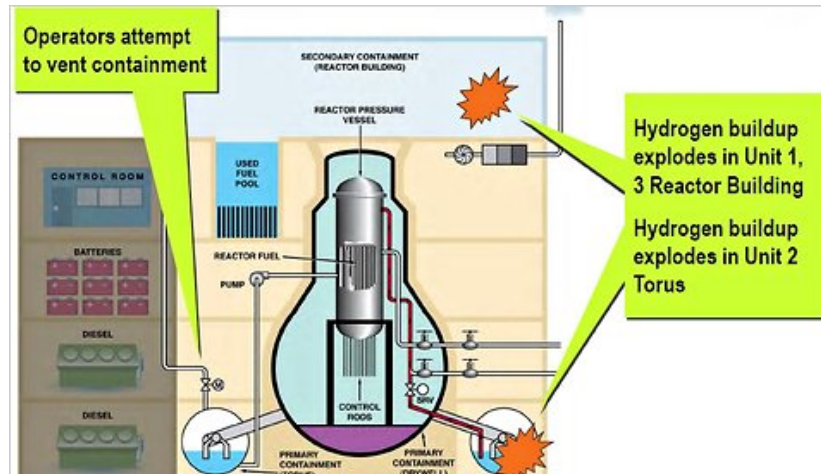
The FILTRA-MVSS is designed to satisfy Swedish regulations requiring 99.9 % of the core inventory of radioactivity (excluding noble gases) be retained in the containment or filtered in case of venting; and it has high decontamination factors for gas-carried particles, aerosols and elemental iodines. It is fully passive for at least 24 hours after initial venting and requires no startup time.

Westinghouse's Filra-MVSS has been installed in 10 Swedish reactors and one Swiss reactor. As described, its benefits include:

- Passive design for at least 24-hours-no operator action required to activate system
- Very high removal efficiencies:
 - Aerosols > 99.00 % decontamination factor (D) > 10,000 with optional fiber filter for smallest particles
 - Elemental Iodine > 99.99% (DF > 10,000)
 - Organic Iodine: > 80% (DF > 5)
 - Same DF for all flow rates
- Designed for all seismic loads
- Designed for a wide range of postulated accidents
- Ability to avoid and cope with oxyhydrogen combustion
- May be used in feed-and-bleed mode for long-term core cooling.

For a BWR such as Pilgrim's, the FILTRA-MVSS would be connected to the hardened vent. Its filter provides several filtration steps, all of which are contained in the tank: the multi-venturi scrubber, a water pool, a moisture separator, and finally an optional metal fiber filter.

Hydrogen Explosions



The reactor explosions at Fukushima were attributed to the ignition of hydrogen gas that collected in the reactor buildings. The hydrogen gas most likely came from a chemical reaction between water and the metal cladding of fuel rods in the reactor core when the water level inside the reactor vessels dropped low enough to expose at least the upper core regions. The hydrogen gas initially collected in the reactor vessel.²⁰

Hydrogen explosions were supposed to be avoided by inerting with nitrogen, but its effectiveness was shown to be limited at Fukushima. The NRC Task Force July 12 Report on lessons Learned from Fukushima reported that venting is the key.

The method of combustible gas control in BWR Mark I and Mark II containments (i.e., containment inerting with nitrogen) will prevent hydrogen fires or explosions as long as containment remains isolated, but it will not eliminate the hydrogen resulting from an accident damaging the core.

This means that in a BWR Mark I or Mark II containment, the hydrogen must be kept in containment by controlling containment pressure without venting (i.e., through heat removal from the containment when possible) or by venting to a safe location.

Venting serves a dual function: overpressure protection & venting of hydrogen: Enhancing the containment venting capabilities for Mark I and Mark II containments, while primarily intended for overpressure protection, would also provide for the reliable venting of hydrogen to the atmosphere. These two steps would greatly reduce the likelihood of hydrogen explosions from a severe accident. [NRC Task Force Report, pg., 42, emphasis added]

Resources, Hydrogen: Mark Leyse, Petition for Rulemaking, that discusses among other things that US simulations of hydrogen explosions in severe accidents are very crude compared to the European simulations – link to PRM-50-103: <http://pbadupws.nrc.gov/docs/ML1130/ML11301A094.pdf>

²⁰ Possible cause of Reactor Building Explosions, David Lochbaum, March 18, 2011 <http://allthingsnuclear.org/dlochbaum/possible-cause-of-reactor-building-explosions>

RADIOACTIVE WASTE

Different Kinds of Radioactive Waste

Radioactive wastes are classified, not according to the threat they pose to human health or the environment, but according to the process which produced the waste. There are two general categories: High Level Waste, and Low Level Waste. One category of Low Level Waste, Greater than Class C Waste, is highly radioactive.

As defined by the NRC:

High Level Waste (HLW) means the highly radioactive materials produced as byproducts of fuel reprocessing or of the reactions that occur inside nuclear reactors. HLW includes:

- Irradiated spent nuclear fuel discharged from commercial nuclear power reactors
- The highly radioactive liquid and solid materials resulting from the reprocessing of spent nuclear fuel, which contain fission products in concentration (this includes some reprocessed HLW from defense activities and a small quantity of reprocessed commercial HLW)

See: <https://www.nrc.gov/reading-rm/basic-ref/glossary/high-level-waste.html>

Commercial Low-Level Radioactive Waste (LLW) is defined by what it is not. It is not high-level radioactive waste, transuranic waste, spent fuel, or by product material (uranium or thorium mill tailings). It includes everything from slightly radioactive trash (such as mops and gloves) to highly radioactive activated metals (such as plutonium) from inside nuclear reactors that are just as radioactive as any High Level Waste. LLW is divided into four categories based on the types of radionuclides and their concentrations: Class A, B, C and Greater-than-Class C; Class A is the least radioactive. Greater-Than-Class C is the most radioactive and generally considered unsuited for near-surface disposal.²¹ Because of its toxicity, it eventually must be stored with spent fuel in a deep repository.

According to the NRC, LLW is:

A general term for a wide range of items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation. A variety of industries, hospitals and medical institutions, educational and research institutions, private or government laboratories, and nuclear fuel cycle facilities generate LLW as part of their day-to-day use of radioactive materials. Some examples include radioactively contaminated protective shoe covers and clothing; cleaning rags, mops, filters, and reactor water treatment residues; equipment and tools; medical tubes, swabs, and hypodermic syringes; and carcasses and tissues from laboratory animals. The radioactivity in these wastes can range from just above natural background levels to much higher levels, such as seen in parts from inside the reactor vessel in a nuclear power plant. Low-level waste is typically stored onsite by licensees, either until it has decayed away and can be disposed of as ordinary trash, or until the accumulated amount becomes large enough to warrant shipment to a low-level waste disposal site.

See <https://www.nrc.gov/reading-rm/basic-ref/glossary/low-level-radioactive-waste-llw.html>

²¹ *High Level Dollars, Low Level Sense*, Institute of Energy and Environmental Research, <http://www.ieer.org/pubs/highlvl4.html>

The states of South Carolina, Texas, and Washington have low-level waste sites. However, the Washington facility does not accept waste from outside its region, and the South Carolina site is available only to the three members of the Atlantic disposal compact (Connecticut, New Jersey, and South Carolina) as of June 30, 2008. The lowest-concentration class of low-level radioactive waste (class A) is accepted by a Utah commercial disposal facility from anywhere in the United States.

Threats by states to close their disposal facilities led to congressional authorization of regional compacts for low-level waste disposal in 1985. The first, and so far, only, new disposal site under the regional compact system opened on November 10, 2011, near Andrews, TX.²² The Texas Legislature approved legislation in May 2011 to allow up to 30% of the facility's capacity to be used by states outside the Texas Compact, which consists of Texas and Vermont.²³

Pilgrim used to send its low-level radioactive waste to Barnwell, South Carolina. Massachusetts lost that option. Now Pilgrim sends it A, B, and C low level radioactive waste to storage in Clive, Utah, after it is blended at the Irwin Resin Processing Facility in Irwin, Tennessee. As of 2017, Pilgrim has one barrel of GTC. That barrel is stored outside, close to Cape Cod Bay. Like spent fuel, it is stranded. Massachusetts General Laws Chapter 111 H established the Low - Level Radioactive Waste Management Board (Board) to manage the options available to the Commonwealth for dealing with low level radioactive waste.²⁴ See its website for information on LLRW in the state.

High-Level Radioactive Waste- Spent Fuel Storage

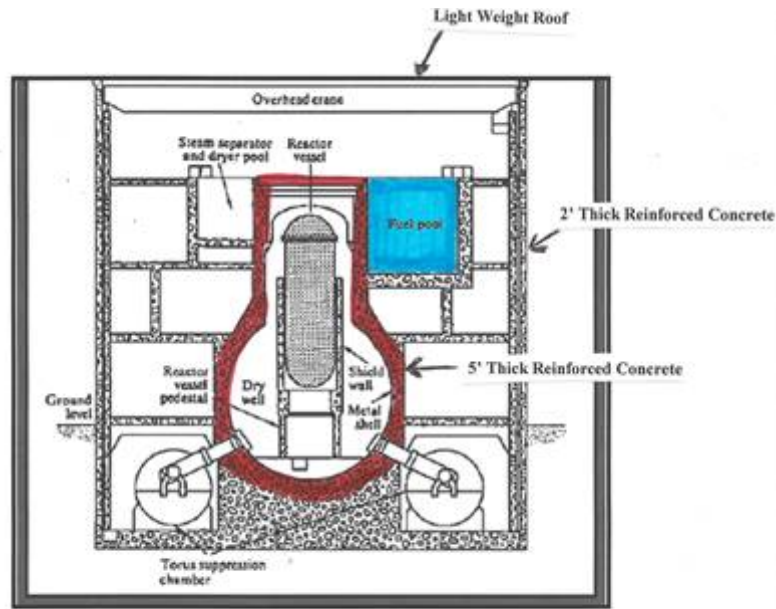
Pilgrim's Spent Fuel Pool

The diagram below shows the inside of Pilgrim's reactor building, and also other GE Mark I BWR reactors. The primary containment is in red; and the spent fuel pool is in blue. Note that the spent fuel pool is high in the reactor building and outside the primary containment.

²² Waste Control Specialists LLC, "Historic Texas Compact Disposal Facility Ready for Business," <http://www.westexas.com>.

²³ Waste Control Specialists LLC, "Waste Control Specialists Commends Passage of Legislation," press release, May 31, 2011, http://www.westexas.com/PDF_downloads/WCSAnnounceslegislation.pdf?nxd_id=98546.

²⁴ See MDPH website for information. <http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/radiation/low-level-radioactive-waste.html>

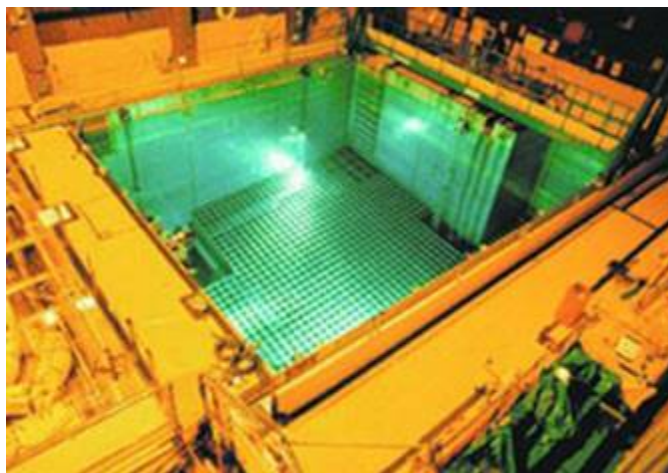


For a brief and highly humorous overview of spent fuel storage watch: John Oliver Scares The Hell Out Of Americans Warning Against Nuclear Waste. <https://www.rawstory.com/2017/08/watch-john-oliver-scares-the-hell-out-of-americans-warning-against-nuclear-waste-rick-perry-is-handling/>

Risks of Spent Fuel Pool Storage

Pool Location; High-Density/Closed-Frame Pool Storage:

Pilgrim's spent fuel pool is located outside primary containment, in the upper floor of the reactor. With only a thin roof overhead it is vulnerable to an air attack, even from a small plane. The pool is densely packed in a closed frame design. It was designed to store 880 assemblies, each of which contains many fuel rods. When Pilgrim was constructed, the plan was that a few spent fuel assemblies would be stored in the pool for a short time, and then would be sent off-site for reprocessing.



Originally, NRC rules required plant owners to maintain empty spaces (580 in the case of Pilgrim) to allow for a full core offload, but this requirement was eliminated.^[2] Pilgrim refuels every two years. Every time it refuels, between about 150 and 200 spent fuel assemblies are moved from the reactor core into the spent fuel pool.

Because President Carter banned reprocessing commercial spent nuclear fuel in 1997, and also because there is no offsite national repository to which commercial spent nuclear fuel can be sent, more and more assemblies are being stored in the spent fuel pool, for longer periods of time. In June of 1994, the NRC gave Pilgrim approval to store 3,859 assemblies in the then 20+ years old spent fuel pool. As part of its 2015 and 2017 refueling, Pilgrim moved 544 assemblies from the pool into eight dry casks (68 assemblies per cask) in its new Interim Spent Fuel Storage Facility (ISFSI). As of August, 2017, there are 2,822 spent fuel assemblies in the spent fuel pool; and 580 assemblies in the reactor core.

Because the pool now contains far more assemblies than the number for which it was originally designed, they are packed in a tight framed configuration with much less spacing between adjacent assemblies. This tight packing places us at risk of an uncontrolled fire, a fire that likely cannot be extinguished. A fire can occur if the coolant water drops to the top of the assemblies as the result of an act of malice, if there is a human or mechanical error, if a cask drops in the pool during transfer to dry cask storage, or a reactor accident migrates to the pool.^[3]

Consequences of a Spent Fuel Pool Fire

- **2016 Princeton Study: A major Spent Fuel Pool fire could contaminate as much as 100,000 square kilometers of land (38,610 square miles) and force the evacuation of millions.**
- **2013 NRC Study: A severe spent fuel pool accident would render an area larger than Massachusetts uninhabitable for decades and displace more than 4 million people.**
- **2006 Massachusetts Attorney General Study: \$488 Billion dollars, 24,000 cancers, hundreds of miles uninhabitable**

Much of the damage from a pool fire would be caused by the release of Cesium-137.

To make the risk meaningful, it is useful to compare the inventory of Cs-137 in Pilgrim's pool and core with the amount of Cs-137 released at Chernobyl.

[2] NUREG-0575 Vol. 1 - <http://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML022550127>

[3] The Massachusetts Attorney General's Request for a Hearing and Petition for Leave to Intervene With respect to Entergy Nuclear Operations Inc.'s Application for Renewal of the Pilgrim Nuclear Power Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Vulnerability of Pilgrim's Spent Fuel Pool- Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants, Gordon Thompson, May 25, 2006

Chernobyl: 2,403,000 curies Cs-137

Pilgrim's pool: 44,010,000 curies Cs-137

Pilgrim's Core: 5,130,000 curies Cs-137

See a recent 2012 GAO Report:, GAO -12-797, Spent Nuclear Fuel: Accumulating Quantities at Commercial Reactors Present Storage and Other Challenges,

<http://www.gao.gov/assets/600/593745.pdf>.

MA Attorney General's 2006 Analysis

- A 2006 analysis for the Massachusetts Attorney General, prepared and submitted to the NRC in connection with Pilgrim's application to extend its operating license from 2012 to 2032, concluded that the offsite consequences in the event of water loss and a pool fire could be as much as \$488 Billion dollars, 24,000 cancers and contamination hundreds of miles downwind.^[4]

NRC's Consequence Study Of A Beyond Design-Basis Earthquake Affecting The Spent Fuel Pool For a U.S. Mark I Boiling Water Reactor (October 2013)^[6]

- NRC's study of spent fuel storage at Peach Bottom, a reactor in Pennsylvania like Pilgrim, showed that if even a small fraction of the inventory of a Peach Bottom reactor pool were released to the environment in a severe spent fuel pool accident, an average area of 9,400.00 square miles (Massachusetts = 6,692.824 square miles) would be rendered uninhabitable for *decades*, *displacing as many as 4.1 million people (MA population=6,692,824)*.

Dr. Frank von Hippel & Michael Schoeppner (Princeton University) Re-analysis of NRC's Study

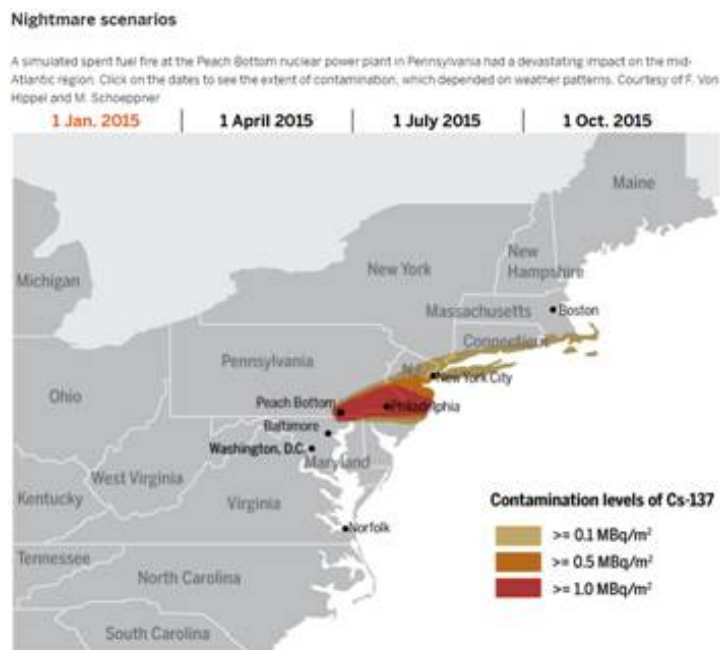
- A more recent study by Frank von Hippel and Michael Schoeppner of Princeton University found that **a major fire could contaminate as much as 100,000 square kilometers (38,610 square miles) of**

^[4] The Massachusetts Attorney General's Request for a Hearing and Petition for Leave to Intervene With respect to Entergy Nuclear Operations Inc.'s Application for Renewal of the Pilgrim Nuclear Power Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Potential Consequences Of A Spent Fuel Pool Fire At The Pilgrim Or Vermont Yankee Nuclear Plant, Jan Beyea, PhD., May 25, 2006 (NRC Electronic Hearing Docket, Pilgrim 50-293-LR, 2—6 pleadings, MAAGO 05/26 (ML061640065) & Beyea (ML061640329)

^[6] Consequence Study Of A Beyond Design-Basis Earthquake Affecting The Spent Fuel Pool For A U.S. Mark I Boiling Water Reactor (October 2013) at 232 (Table 62) and 162 (table 33), Adams Accession NO ML13256A342)

land and force the evacuation of millions. [7] It would dwarf the accident at Fukushima resulting in trillion-dollar consequences.

- The researchers noted that NRC's 2013 study, referenced above, did not evaluate the risk of terrorism or insider sabotage as it considered spent-fuel pool safety; neither did it consider the consequences of property contamination more than 50 miles from the reactor site, even though a broader release is clearly possible. Also, NRC used outmoded statistical estimates for the value of human life; did not incorporate potential tourism losses after an accident or consider the potential costs to the economy if a major accident forced multiple reactors to be shut down.
- The Princeton researchers did not use the computer model (MACCS2) that NRC used at Peach Bottom but instead used HYSPLIT, a program able to design more sophisticated scenarios based on historical weather data for the whole region.
- The researchers focused on Cs-137, a radioisotope with a 30-year half-life that has made large tracts around Chernobyl and Fukushima uninhabitable. They assumed a release of 1600 petabecquerels, which is the average amount of Cs-137 that NRC estimates would be released from a fire at a densely packed pool. That amount is approximately 100 times the amount of Cs-137 spewed at Fukushima. They simulated the release on the first day of each month.
- The geographical extent of the "nightmare scenario" of a spent fuel pool fire at Peach Bottom is shown below. For Pilgrim, move it about 300 miles to the northeast; and imagine what the picture would be if the wind happened to be from the southeast.



[7] Frank N. von Hippel, Michael Schoeppner, "Reducing the Danger from Fires in Spent Fuel Pools," *Science & Global Security* 24, no.3 (2016): 141-173 <http://scienceandglobalsecurity.org/archive/sgs24vonhippel.pdf>.
Richard Stone, "Spent fuel fire on U.S. soil could dwarf impact of Fukushima," *Science*, May 24, 2016. (available at: <http://www.sciencemag.org/news/2016/05/spent-fuel-fire-us-soil-could-dwarf-impact-fukushima>)

Naoto Kan was the Prime Minister of Japan when the Fukushima accident occurred. He summarized the danger of spent fuel storage in a PBS documentary early 2017. After being informed about the consequences if the spent fuel in Fukushima Unit 4 pool had caught fire, [he said](#) “[W]e would have to evacuate 50 million people. It would have been like losing a major war... I feared decades of upheaval would follow and would mean the end of the State of Japan.”

Spent Fuel Vulnerability

- **Electric Power is Required to Operate Safety Systems Needed for Pool:** Contary to what one might expect, nuclear power plants do not generate the electricity their safety systems. Because nuclear plants often shutdown, for a variety of reasons, these safety systems depend on off-site power (or on onsite-back-up systems if needed) for the electric power needed to cool, maintain or makeup water in the spent fuel pool. Neither offsite nor onsite electric power is assured, as discussed below. The spent fuel pool should, but does not, have its own backup power.
- **Pool Instrumentation:** Currently there is no instrumentation in the pools to measure both water level and temperature. The NRC Post Fukushima Order (EA-12-051, March 12, 2012) required pool instrumentation to measure only water level, not temperature, and gave licensees until two refueling cycles after submittal of the integrated plan or by December 31, 2016 – whichever comes first- to implement the order. The spent fuel pool instrumentation order is accessible here: <http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/spent-fuel.html>
- **Security:** Pilgrim’s spent fuel pool is a vulnerable target and capable of catastrophic destruction,^[8] discussed in the following section “Security.”
- **Boraflex Panels:** To prevent criticality in pool from assemblies packed too closely together, boraflex panels were added to separate the assemblies. 900 are degraded, (04/17).

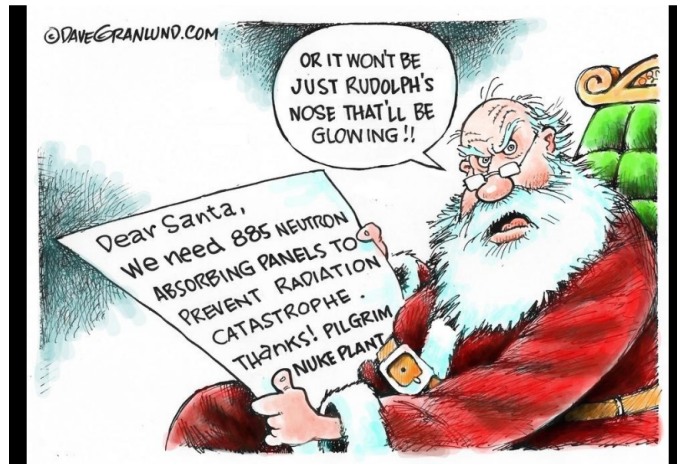
A (08.31.17) email to Pilgrim Watch from NRC said that: “Entergy’s current plan, as it has been communicated to the NRC, entails two phases. The first phase (which has already been completed by Entergy and assessed by the NRC) was to re-arrange fuel in the spent fuel pool to guarantee that, based on the spatial separation of the fissile material, the subcriticality of the pool will remain within regulatory limits past September 2017. The second phase of the plan will be to move fuel into dry storage casks in order to ensure that subcriticality will remain within regulatory limits once the core fully is offloaded into the spent fuel pool in 2019. Cask-loading activities are scheduled to take place next year, and the NRC will be performing associated inspections in accordance with NRC Inspection Procedure 60855.”

Further NRC said that, “At present, with no additional fuel added to the pool, the plant does not require any additional fuel movement to address the boraflex panel degradation to maintain subcriticality. However, the current configuration of the spent fuel pool, taking into account current and projected boraflex panel degradation, would not allow for the offloading of all of the fuel that is currently in the reactor core into the pool when the plant shuts down in 2019. For this reason, some

^[8]The Massachusetts Attorney General’s Request for a Hearing and Petition for Leave to Intervene With respect to Entergy Nuclear Operations Inc.’s Application for Renewal of the Pilgrim Nuclear Power Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Vulnerability of Pilgrim’s Spent Fuel Pool- *Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants*, Gordon Thompson, May 25, 2006;

of the fuel currently in the pool will need to be moved to dry-cask storage before the fuel in the core can be fully offloaded into the pool in 2019.”

Granlund cartoon: Pilgrim Nuclear Plant



National Academy of Sciences, “Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Plants: Phase 2,” May 2016^[9]

The Academy’s [Phase 2](#) report provides findings and recommendations for improving U.S. nuclear plant security and spent fuel storage as well as re-evaluates conclusions from previous Academy [studies](#) on spent fuel storage safety and security.

Highlights of the Report: *Lessons Learned from the Fukushima Daiichi Accident for Spent Fuel Storage.* The U.S. nuclear industry and its regulator should give additional attention to improving the ability of plant operators to measure real-time conditions in spent fuel pools and maintain adequate cooling of stored spent fuel during severe accidents and terrorist attacks. These improvements should include hardened and redundant physical surveillance systems (e.g., cameras), radiation monitors, pool temperature monitors, pool water-level monitors, and means to deliver pool makeup water or sprays even when physical access to the pools is limited by facility damage or high radiation levels. The U.S. Nuclear Regulatory Commission should perform a spent fuel storage risk assessment to elucidate the risks and potential benefits of expedited transfer of spent fuel from pools to dry casks. This risk assessment should address accident and sabotage risks for both pool and dry storage.

NRC’s Response to the Dangers of Pool Storage After Fukushima

After the Fukushima nuclear disaster, the NRC largely left it up reactor operators to provide their own strategies to address what is known as a beyond-design-basis that caused the loss of water in Fukushima’s spent fuel pool. Some of those strategies seem less than robust.

For instance, the strategy to replace spent fuel pool water at Pilgrim involves moving a pumper truck from its garage to the edge of Cape Cod Bay, and then connecting it to a “Rube-Goldberg” designed pulley

^[9] Available at: <http://www.nap.edu/catalog/21874/lessons-learned-from-the-fukushima-nuclear-accident-for-improving-safety-and-security-of-us-nuclear-plants>

system so that it can pump water out of the bay. The system seems unlikely to work during a Nor'easter, a terrorist attack or in high radiation. Pilgrim added water level monitors to the pool but it did not add temperature monitors.

NRC was satisfied with the steps taken by Entergy and the industry. NRC officials told a panel of the National Academy of Science in 2013 that “no early fatalities are predicted in any scenarios” studied in response to the Fukushima disaster. A pool fire, [the NRC said](#), would result in “exposures to very lightly contaminated areas for which doses are small enough to be considered habitable.” These conclusions are wishful thinking.



Fukushima Daiichi, Unit 4- Hose adding water to pool, reactor building is a shell after explosion

Ways to Reduce the Risk of Spent Fuel Pool Fires

Return Pool To Its Original Design - Low Density, Open-Frame

Return pool to low density, open-frame design so that if the water level drops there can be enough air convection to provide cooling to prevent an immediate fire, and also allow time to fix the coolant water problem. Also, move the assemblies more than 5 years out of reactor, when they are thermally cool enough, out of the pool and into hardened, dry cask storage onsite until an acceptable offsite solution is provided. Casks are much safer because they do not require mechanical parts or human intervention to function. They are passive.



Entergy – Plans To Transfer Assemblies From Pool To Dry Casks Within 3 Years After Closure

This is an economic decision. Once the pool is emptied operating expenses sharply decrease and decommissioning, removal of the reactor, can begin.

Who will pay? Not out of the licensee's pocket.

- **Decommissioning Trust Fund (DTF) used for spent fuel management.** NRC has allowed the Decommissioning Trust Fund (DTF), supposedly reserved only for post-shut down expenses to remove radioactivity, to be used instead for spent fuel management. Therefore, instead of using the licensee's own operating and management budget to thin the pool during operations, the licensee postpones transfer to dry casks until operations cease and then they can dip into the DTF. Entergy has not put a dime of its own money into the fund; instead, Entergy received the fund from Boston Edison when it bought Pilgrim. States object to using the decommissioning funds for spent fuel management because the decommissioning funds are viewed as woefully inadequate.
- **DOE Law Suits:** Entergy will sue DOE for breach of contract for failing to take the fuel by 1998 to recover its spent fuel management costs. In a fair world, the monies recovered from DOE should be returned to the decommissioning trust fund to replenish it for what was or might be taken out. NRC has no such requirement. If Holtec becomes the licensee when Pilgrim ceases operation, it is likely to get \$500+ million in DOE reimbursements to add to its profits.

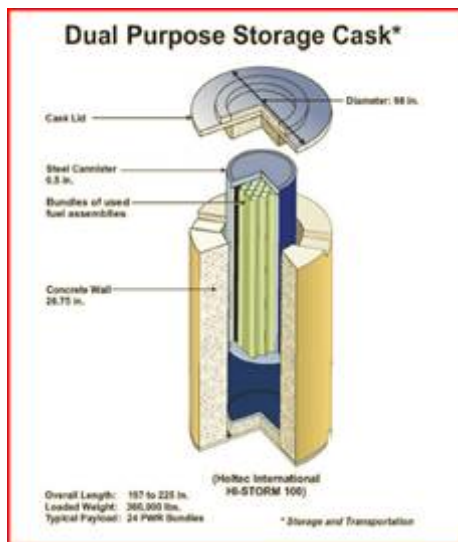
Pilgrim's Dry Cask Storage

Spent Fuel Dry Casks

Casks: Entergy is using Holtec Hi-Storm 100, Version B, MPC-68 casks to eventually hold and store 61 dry casks filled with highly radioactive spent fuel assemblies. Additional casks likely to store Greater-Than-

Class-C radioactive waste that must go to a deep geological repository too. The cask system is comprised of three primary components: MPC-68, HI-TRAC 100 D, and HI-STORM 100S. The MPC-68 is a metal canister that has a storage capacity of 68 BWR spent fuel assemblies. The HI-TRAC (transfer cask) is a metal transfer cask that provides a means to lift and handle the canister as well as providing radiological shielding of the spent fuel assemblies. The HI-STORM 100-S Version B storage overpack is a stainless steel-encased concrete storage cask that provides physical protection and radiological shielding for the metal canister when in storage. The storage cask is vented for natural convection to dissipate the spent fuel decay heat. The casks are stored in a vertical position outdoors on a storage pad.^[11]

^[11] Entergy Letter No. 2.13.042, pg., 3 ([NRC Electronic Library, ADAMS, Accession Number ML13346A026](#))



Each loaded cask inside the pool weighs **40 tons**, the equivalent of about 7 adult male African elephants. The casks will be placed on a concrete storage pad 52' X 238.5' located about 100 yards from the shore at 25 MSL. Each cask, with its overpack, weighs about **200 tons when placed on the outside pad**. The pad is not enclosed or covered in any way.

Pilgrim prior to closure May 31, 2019 will have seventeen (17) loaded Holtec System 100 Multi Purpose Canisters (MPCs) containing 1,156 fuel assemblies. A total of 4,114 spent fuel assemblies will be required to be stored at Pilgrim Station. The entire dry fuel storage campaign is expected to require 61 casks. A second ISFSI pad is required to store all spent nuclear fuel on-site. The site will have one fuel storage location to minimize operational costs.

The casks will be onsite for a long-time. The NRC's Continued Storage final rule and generic environmental impact statement claimed that the spent fuel assemblies may be safely kept in dry casks onsite for 300 years or more, assuming that the dry cask pad and casks are changed every 100 years.

Transfer of Spent Fuel From Pool To Dry Casks

The following links show the transfer process. Although Pilgrim uses a different cask and stores the casks vertically on the pad, the process is essentially the same as shown on the videos:

- <http://www.youtube.com/watch?v=9eFxP0VFdt0> - NUHOMS Used Nuclear Fuel Loading
- http://www.youtube.com/watch?v=mlLvWNgggfU&feature=player_embedded
- <http://www.muzikkitabi.com/Video/VIDEOIDrh6FeQWuhCs/Dry-Cask-Storage-For-Spent-Fuel-At-Nuclear-Energy-Plants>

Pilgrim's Preparation for Transfer: Pilgrim applied to the NRC for a license amendment in order to begin the transfer process.^[12] Prior to transfer, the pool was licensed only for transferring assemblies that themselves weigh about 2,000 lbs; but a loaded cask even when in the pool weighs 40 tons. Pilgrim's license required an energy absorbing pad in the floor of the pool to protect it from a drop.

^[12] Docket ID NRC-2014-0202, 56608 Federal Register / Vol. 79, No. 183 / Monday, September 22, 2014 / Notices

Entergy removed the pad prior to asking for a license amendment. The application justified Pilgrim's readiness for the transfer operation by installing the various changes: upgrading the crane to single failure proof; removing the energy absorbing pad, after the fact; and installing a leveling platform.

Safety Issues Transfer:^[13] Entergy remained operating during the dry run exercise and two actual transfers to dry cask storage. In future cask transfers, Pilgrim will remain operating. NRC's Ray McKinley in response to a question from Pilgrim Watch said:

The Certificate of Compliance for the spent fuel storage cask requires a dry run training exercise of the activities associated with dry cask loading prior to the first use of the system to load spent fuel assemblies. Pilgrim's dry run is being conducted in four phases which are being observed by the NRC. A specially designed simulated MPC will be utilized that approximates the 40 ton weight of an MPC loaded with fuel. The plant will not be shut down during the dry cask loading activities. It is not necessary. The safety features of the crane and the designated heavy loads path in the reactor building protect plant systems.

Pilgrim should not operate during transfer: NRC allows Pilgrim to operate during the transfer process because the transfer crane was upgraded to single-failure proof that reduces, but that does not eliminate a possible drop. We believe operations should cease during transfer because although the probability of a drop may be small, the consequences are too great. Accidents can and do happen, even with single-proof cranes. For example at Vermont Yankee (May 2008) the brakes on the crane didn't function properly and it almost dropped a load of high-level radioactive waste during the first removal of spent fuel assemblies from the spent fuel pool into a cask for dry cask storage outside of the plant. According to reports at the time, the brakes on the crane did not respond properly because its electrical relays were "out of adjustment." The cask came within 1½ inches of the floor, when the operator wanted it to stop four inches above the floor. Another mishap or near-miss with a single-proof crane occurred at Palisades.

Canister Drop in the pool: If a cask is dropped in the pool and the pool floor is breached, there are many safety-related components located on the floors below the spent fuel pool which could be disabled that could simultaneously initiate an accident and disable accident mitigation equipment.

Canister Drop on the reactor building floor once removed from the pool and lowered to prepare for transfer outside the building to the storage pad: If a cask is dropped on the reactor building floor once it is removed from the pool, a drop could induce relay chatter or the opening and/or closing of relay contacts. This may result in important equipment being rendered inoperable such as valves erroneously opened or closed, pumps shut off, and loss of indications of the status of safety systems.

NRC Guidance: Entergy, however, was not required to analyze the impact of a canister drop inside the pool or, we presume, analyze the impact of a canister drop, once removed from the pool, onto the reactor building floor. NRC licensing guidelines accept the hypothesis that what it calls a highly reliable handling system eliminates any need for a load drop analyses. Therefore, going forward, Entergy will credit the handling system rather than a load drop analysis as the basis for safe handling of the canisters, both in the spent fuel pool and when lowering the cask onto the transporter.

^[13] Email correspondence Raymond McKinley Chief, Division of Reactor Projects Branch 5 U.S. NRC Region and Mary Lampert, Pilgrim Watch/Duxbury Nuclear Advisory Committee-available on request.

Pilgrim Watch believes that there are no guarantees. The operators moving the casks are not failure-proof, neither are the operators or designers and workers at factories manufacturing the crane and its accessory structure's parts. There were problems at Entergy's Palisades NPS^[14] and Vermont Yankee NPS,^[15] both had failure-proof cranes.

Entergy is not required to have an energy absorbing pad on the floor of the pool. Again the rationale is that they have a single-failure proof crane; and also they installed a leveling platform.

David Lochbaum, Union of Concerned Scientists, reported that:^[16]

In December 1987, an operator at the Wolf Creek nuclear plant near Burlington, Kansas, forgot to close a valve in the pipe connecting the spent fuel pool to the refueling water storage tank. The open valve allowed gravity to drain water from the spent fuel pool to the tank.

The control room operators did not notice the spent fuel pool water level dropping steadily during the next two days. The spent fuel pool water level was not routinely recorded. Operators relied on the spent fuel pool low level alarm to warn them. Unfortunately, the level alarm was not functioning properly, and no warning was issued when the level dropped below the alarm point.

The operators also failed to notice the rising level in the refueling water storage tank during these two days. Luckily, at least 22 feet of water remained over the irradiated fuel assemblies in the spent fuel pool despite the lax monitoring by several consecutive shifts of operators.

Our Takeaway: Had the water level dropped another few feet, high radiation fields in and around the fuel handling building could have made it difficult for workers to recover from the situation once it was finally noticed. Radiation alarms would have ultimately clued operators into the spent fuel pool drainage problem; that is, assuming that the radiation alarms would have worked.

It takes only one equipment failure or worker mistake to cause radioactive materials to be released. Such failures and mistakes happen more often than they should.

^[14] <http://www.nirs.org/reactorwatch/licensing/caskdanglesummaryreport4406.pdf>

^[15] <http://www.timesargus.com/article/20141104/NEWS03/711049924>

^[16] <http://allthingsnuclear.org/dlochbaum/fission-stories-112-if-i-only-had-a-drain-trouble-at-the-wolf-creek-spent-fuel-pool>

Preparations for a seismic event: Entergy analyzed the equipment for a seismic event. The analysis is “proprietary”.^[17] Pilgrim Watch was informed by NRC’s Ray McKinley that the seismic analysis was based on previous expectations not on the more severe events that we can now expect in the future.^[18] We asked NRC if both the bridge and the trolley were fitted with seismic restraints to maintain the crane on the girder and runway rails. No answer to date.

Vertical Cask Transporter (VCT) to move the cask from the reactor building to the pad: The VCT uses foam filled rubber tires. We understand that rubber tires have advantages in seismic situations (rubber tires have elasticity and a lower center of gravity) and foam fill prevents flat-spotting, loss of pressure, blow-outs and prevents damage to travel surface.

Dry Cask Storage Issues^[19]

Although dry cask storage is far safer than pool storage, there are problems to consider. According to the Nuclear Regulatory Commission (NRC):

- The thin (0.5”) stainless steel canisters may crack within 30 years.
- No current technology exists to inspect, repair or replace cracked canisters.
- With limited monitoring, we will only know after the fact that a cask has leaked radiation.

^[17] Holtec Proprietary Report HI-2104715 Rev. 7 "Seismic Analysis of the Loaded H1-TRAG in the SFP and SFP Slab Qualification" (112 Pages) Entergy Response to NRC Request for Additional Information (RAI), Regarding the Heavy Loads License Amendment Request (TAC NO. MF3237) OCT 3, 2014, NRC Adams Library, ML14280A230

^[18] The updated seismic data shows that Pilgrim could feel the effects of earthquakes as far away as 400 miles, double the previously estimated distance. Senators Markey and Warren in a letter to NRC Chair Macfarlane,^[18] March 31, 2014 noted that, “The new seismic hazard was found to exceed the safe shutdown earthquake at the ground shaking frequencies that are most likely to threaten the equipment needed to safely shut down the reactor.” Further, the Senators expressed special concern about Entergy’s March 10 request to the NRC asking for permission to alter some of the numbers used to model the geologic properties of the bedrock on which the Pilgrim nuclear plant sits to “prevent unjustified alarm by stakeholders when GMRS [ground motion response spectrum] results are made public.”

On May 2014 Entergy completed a seismic walk-down at Pilgrim. The NRC staff assessment of the walk-down concluded that, “... the licensee, through the implementation of the walk-down guidance activities and, in accordance with plant processes and procedures, verified the plant configuration with the current seismic licensing basis; addressed degraded, nonconforming, or unanalyzed seismic conditions; and verified the adequacy of monitoring and maintenance programs for protective features. Furthermore, the NRC staff notes that no immediate safety concerns were identified.”^[18] But, significantly NRC failed to say that the seismic walk-downs were based on earlier and outdated understanding of seismic risk here.

^[19] San Onofre Dry Cask Storage Issues analyses at: <https://sanonofresafety.files.wordpress.com/2011/11/drycaskstorageissues2014-09-23.pdf>

The Nuclear Regulatory Commission's (NRC), Waste Confidence Final Rule 2014 said that spent fuel can be stored at nuclear plants for 60 years (short-term), 100 years (long-term) and thereafter indefinitely^[20]. But the NRC currently only certifies dry cask storage systems for 20 years, so we cannot depend on the NRC for assurances that these cask systems will for even the 60 year short term. The NRC, the Electric Power Research Institute (EPRI), and numerous government and scientific sources report the following problems with the current steel/concrete U.S. spent nuclear fuel dry storage systems:

Canisters may need to be replaced within 30 years or sooner - Stress Corrosion Cracking: The thin 1/2" welded stainless steel canisters may have premature stress corrosion cracking within 30 years, caused by our marine environment.^[21] This could result in major radiation releases. Cracks in similar materials at nuclear power plants caused component failures in less than 30 years, including at San Onofre^[22]. Other cask systems, such as the German CASTOR V/19 (~20" thick) ductile cast iron casks, do not have this problem.^[23] The concrete overpacks also have aging issues that are accelerated in coastal environments.

Our Recommendation: The casks will be stored outside on a pad, perhaps indefinitely. Because the Holtec system is susceptible to stress corrosion cracking exacerbated by a salt environment, Pilgrim Watch believes the ISFSI should be inside a building.

No technology to adequately inspect canisters for stress corrosion cracking. There is no technology to inspect even the outside of the stainless-steel canisters for cracks once they are loaded with nuclear waste (spent nuclear fuel).^[24] The NRC is giving the nuclear industry five years to develop a method to inspect the outside of the canisters. And then they only plan to require inspection of one canister at each nuclear plant, after 25 years of service and then subsequently every year. Cask systems, such as the German CASTOR, can be inspected since they do not need concrete overpacks for gamma ray and neutron protection.

Our Recommendation: More robust aging management program sampling multiple casks, with more frequent inspections.

^[20] U.S Nuclear Regulatory Commission's (NRC) Nuclear Waste Confidence renamed Continued Storage of Spent Nuclear Fuel Generic Environmental Impact Statement (GEIS) and Rule, 79 Fed. Reg. 56,238-56,263 (Sept. 19, 2014) (Effective October 20, 2014). The decision is under appeal by the NY, MA, Vermont AGO and independent groups.

^[21] Chloride-Induced Stress Corrosion Cracking Tests & Example Aging Management Program, Darrell S. Dunn, NRC/NMSS/SFST, Public Meeting with NEI on Chloride Induced Stress Corrosion Cracking Regulatory Issue Resolution Protocol, August 5, 2014 <https://sanonofresafety.files.wordpress.com/2013/06/8-5-14-scc-rirp-nrc-presentation.pdf>

^[22] Outside Diameter Initiated Stress Corrosion Cracking Revised Final White Paper, PA-MS-0474, October 13, 2010, Ryan Hosler (AREVA), John Hall (Westinghouse) <http://pbadupws.nrc.gov/docs/ML1104/ML110400241.pdf>

^[23] Top 10 Reasons to Buy Thick Casks, San Onofre Safety at: <https://sanonofresafety.files.wordpress.com/2014/10/thincanistersvsthickcasks2014-10-14.pdf>

^[24] EPRI Extended Storage: Research Perspective, John Kessler, EPRI Used Fuel and High-Level Waste Management Program, NWTRB Meeting, September 14, 2011 <http://www.nwtrb.gov/meetings/2011/sept/kessler.pdf>

No remediation plan to repair failed canisters. Technology used for other stainless-steel components cannot be used to repair canisters containing nuclear fuel waste.^[25] The NRC stated that if one of the canisters becomes defective (e.g. 75% through-wall stress corrosion cracks), there is no way to repair or replace the canister; especially if the spent fuel storage and transfer pools are demolished, as licensees have done when decommissioned. And before a canister can be transported (inside a transport cask), the canister must not have cracks. The NRC is optimistic there will be a solution before it is needed. However, they do not know what that might be.

Our Recommendation: Store spare overpacks onsite.

No current method to replace failing canisters. The only fuel-handling method currently available to the commercial nuclear generating industry is to bring a cask [or canister] back into a spent fuel pool for reopening.

Dr. Kris Singh, CEO, Holtec International said that,

...It is not practical to repair a canister if it were damaged... You will have... millions of curies of radioactivity coming out of canister... A canister that develops a microscopic crack (all it takes is a microscopic crack to get the release), to precisely locate it... And then if you try to repair it (remotely by welding) ... the problem with that is you create a rough surface which becomes a new site for corrosion down the road. I don't advocate repairing the canister.

However, dry handling of the cask and fuel is important to avoid disturbing the properties of the cask, cladding, fuel, and related hardware that would occur if the materials were rewetted and rapidly cooled. However, there is no dry handling facility available in the nation that is large enough to handle these canisters. ...and removal of a welded storage cask lid is problematic^[26]. There is also no dry handling (hot cell) mobile facility designed for this purpose and one may not even be feasible.^[27]

Our Recommendation: Develop and build the equipment that it needed as quickly as possible. We cannot risk thousands of thousands of casks of spent nuclear fuel, spread throughout the United States, with no way to repair or replace them.

Criticality and Cracking Risks: Holtec admitted to the NRC that if unborated water enters the canister a criticality can occur. The NRC confirmed this. However, NRC claims canisters won't have through-wall cracks, so it will not happen. They ignore the fact that even microscopic scratches, pits or other corrosion, such as from moist salt air, can trigger cracking. They admit once a crack starts it can grow through the wall in only 16 years. Their original estimate it would take 30 years for a crack to start has been proven wrong. The NRC admits moisture with salt is one of the major triggers for cracking of these stainless steel thin-wall canisters.

[25] EPRI Extended Storage: Research Perspective, John Kessler, EPRI Used Fuel and High-Level Waste Management Program, NWTRB Meeting, September 14, 2011 <http://www.nwtrb.gov/meetings/2011/sept/kessler.pdf>

[26] Viability of Existing INL Facilities for Dry Storage Cask Handling, Rev. 1, April 30, 2013, Randy Bohachek, et al., Idaho National Lab <http://energy.gov/sites/prod/files/2013/12/f5/INLFacilitiesDry%20StorageCaskHandlingViabilityRptR1b.pdf>

[27] Technical Workshop on the Impacts of Dry-Storage Canister Designs on Future Handling, Storage, Transportation, and Geological Disposal of Spent Nuclear Fuel in the United States, NWTRB, November 18-19, 2013.

The **Nuclear Waste Technical Review Board** (NWTRB) December 2017 report to the United States Congress and the Secretary of Energy, Management and Disposal Of US Department Of Energy Spent Nuclear Fuel is pertinent to storage at commercial reactors.²⁵

The NWTRB oversees the DOE management of both commercial and defense nuclear waste. The Nuclear NWTRB recommends spent nuclear fuel and its containment must be monitored and maintained in dry storage in a manner to prevent hydrogen gas explosions for both short-term and long-term storage and transport. This is not currently being done. The Board makes six recommendations that include monitoring of spent nuclear fuel and the containers to prevent known explosion and criticality risks and other risks in storage and transport. They acknowledge the DOE is not currently doing this. The NRC approves containers that do not meet the NWPA legal requirement for fuel retrievability and do not meet the NWTRB requirements recommended in this report.

There are no monitors installed on each cask to measure heat, helium (to provide early warning) and radiation. The NRC's reasons that there are not, once again, unconvincing: The canisters to be used at Pilgrim's are welded closed and therefore do not require the use of instrumentation to assure the safe storage of spent fuel. Prior to being placed on the ISFSI pad, the welds are examined and tested to confirm their integrity, and radiation measurements are taken. In accordance with the CoC for the HOLTEC HI- STORM 100 system, surveillance of the passive heat removal system (air inlet and outlet vents) is required daily to ensure system operability. This can be achieved by either monitoring the inlet and outlet vent temperatures or performing a visual inspection daily to ensure that the vents are not blocked. Pilgrim has elected to perform daily visual inspections to ensure the air inlet and outlet vents do not become blocked and the passive heat removal system remains operable.

NRC also says that Thermoluminescent dosimeters (TLDs) will be placed around the ISFSI (cask storage pad). Ray McKinley said that "The NRC intends to inspect Entergy's plans for radiation monitoring of their independent spent fuel storage installation (ISFSI) at Pilgrim during upcoming inspection activities. Typically we have seen licensees at other sites install thermoluminescent type dosimeters at the ISFSI periphery. The frequency that licensees have performed radiological monitoring from dosimeters has varied from quarterly to yearly based on their specific program requirements. The results of radiological monitoring associated with the ISFSI are included in the licensee's REMP report."

Our Recommendation: The public would be better protected if each cask had heat, , and radiation monitors, considering that the canisters and concrete outer packs are prone to cracking and, especially in our environment, corrosion. TLDs only provide an average figure, can only read to a maximum threshold, that is, like a film badge they can only read so high, and do not read high or low alpha and beta.

Blocking Air Ventilation Vents: Casks have air holes at bottom and top of casks for ventilation. If the holes are blocked by ice, snow, debris, or bird nests cooling will not occur.

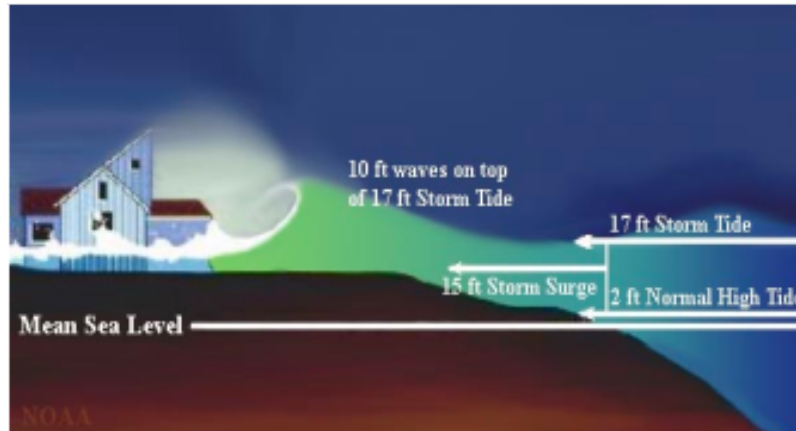
Our Recommendation: Provide mitigation to prevent blockage, such as placing casks inside an enclosed building or installing an overhead roof and ensure in the design that there is drainage around each cask.

Vulnerability Pilgrim's current ISFSI to Flooding: Pilgrim's casks during operations are stored on a concrete pad < 200 yards from Cape Cod Bay at 25 feet MSL. Flooding from sea level rise and storm

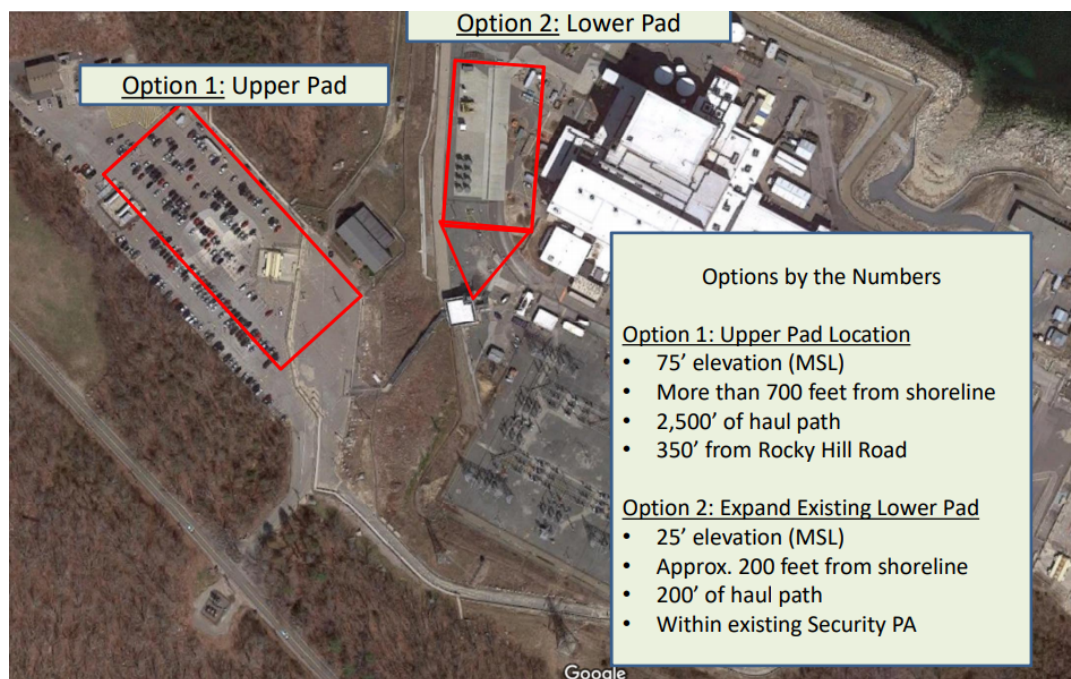
²⁵<http://www.nwtrb.gov/docs/default-source/reports/nwtrb-mngmntanddisposal-dec2017-508a.pdf?sfvrsn=12>.

surges are predicted to increase during the years. The licensee agreed to move the ISFSI to higher ground, 300' from Rocky Hill Road.

Vulnerability: 15 ft surge on a 2 ft tide + 17ft storm tide + 10 ft waves = 27ft above MSL



Entergy announced that it will move the ISFSI to higher ground (Option 1, Upper Pad) and transfer all casks to the new location by 2020-2021.²⁶

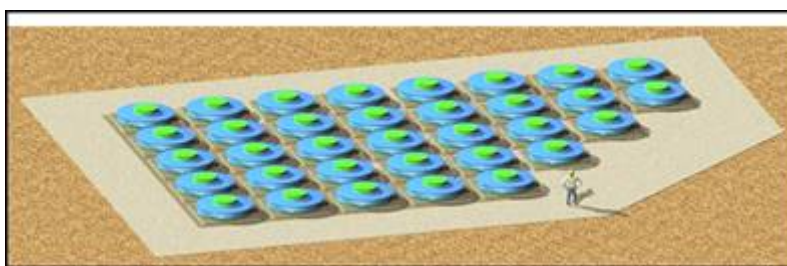


²⁶ <https://www.mass.gov/files/documents/2018/10/26/10-24-18-pilgrim-ndcap-presentation.pdf>

Casks are vulnerable to attack: Pilgrim's casks will be lined up vertically on a pad, in an arrangement referred to as "candlepin bowling for terrorists." Casks are vulnerable from an air or land-based attack with weapons readily available today. [28] Yet despite their vulnerability, the NRC commissioners voted to approve a staff proposal submitted on September 11, 2015^[29] to postpone the schedule for developing new requirements for protecting spent fuel in dry cask storage from sabotage by five years. There are several good reasons to implement this rule sooner. The most important one is that the current rules do not provide adequate protection of dry casks from certain types of terrorist attack scenarios, as the NRC has acknowledged publicly. The ISFI's new location is near a public road presenting a security threat from line-of-sight attack. Please see security section beginning on pg., 53.



San Onofre is installing the HI-STORM 100U module. **Critics advise that** Holtec HI-STORM UMAX canister storage systems and other Holtec thin canister storage systems cannot be inspected, repaired, adequately monitored, and have all the conditions for stress corrosion cracking. Canisters with cracks cannot be transported according to [NRC Regulation 10 CFR § 71.85](#). **Further, it is** not practical to repair a damaged canister, says Dr. Kris Singh, CEO, Holtec International. To read a discussion of these casks, please visit <http://sanonofresafety.org/holtec-hi-storm-umax-nuclear-waste-dry-storage-system/>



<http://www.holtecinternational.com/productsandservices/wasteandfuelmanagement/hi-storm/hi-storm-100u/>

[28] The Massachusetts Attorney General's Request for a Hearing and Petition for Leave to Intervene With respect to Entergy Nuclear Operations Inc.'s Application for Renewal of the Pilgrim Nuclear Power Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Vulnerability of Pilgrim's Spent Fuel Pool- *Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants*, Gordon Thompson, May 25, 2006; *Environmental Impacts of Storing Spent Nuclear Fuel and High-Level Waste from Commercial Nuclear Reactors: A Critique of NRC's Waste Confidence Decision and Environmental Impact Determination*, Dr. Gordon Thompson, February 6, 2009, pgs., 29, 47, 50, Tables 7-6, 7-7.

[29] <http://allthingsnuclear.org/elyman/ominous-votes-by-the-nrc>

Potential for Release from a Cask and Consequences

Dr. Gordon Thompson observes that: Casks are not robust in terms of its ability to withstand penetration by weapons available to sub-national groups. A typical cask would contain 1.3 MCi of cesium-137, about half the total amount of cesium-137 released during the Chernobyl reactor accident of 1986. Most of the offsite radiation exposure from the Chernobyl accident was due to cesium-137. Thus, a fire inside an ISFSI module, as described in the preceding paragraph, could cause significant radiological harm.

Dr. Thompson's analysis of the impact of a shaped charge on a dry cask is discussed below - Pilgrim is vulnerable to attack- while operating and when closed.

Options to reduce risk: Use thick-walled metal casks, dispersal of the casks, and protection of the casks by berms or bunkers in a configuration such that pooling of aircraft fuel would not occur in the event of an aircraft impact.

Holtec has developed a design for a new ISFSI storage module that is said to be more robust against attack than present modules. The new module is the HI-STORM 100U module, which would employ the same canister used in the present Holtec modules. For most of its height, the 100U module would be underground. Holtec has described the robustness of the 100U module as follows^[31]:

"Release of radioactivity from the HI-STORM 100U by any mechanical means (crashing aircraft, missile, etc.) is virtually impossible. The only access path into the cavity for a missile is vertically downward, which is guarded by an arched, concrete-fortified steel lid weighing in excess of 10 tons. The lid design, at present configured to easily thwart a crashing aircraft, can be further buttressed to withstand more severe battlefield weapons, if required in the future for homeland security considerations. The lid is engineered to be conveniently replaceable by a later model, if the potency of threat is deemed to escalate to levels that are considered non-credible today."

Liability – Who is responsible if there is a problem - Entergy or Holtec? Casks will remain onsite for decades. Holtec is just another company, arranged like Entergy, with multi-tiered limited liability companies none of which have the assets to deal with any significant problem. We understand the warranty at SanOnofre, for example, says that Holtec can transfer the warranty to another company at any time. What does Pilgrim's cask warranty say? San Onofre's warranty is limited to manufacturing defects for 25 years.

National Academies: Congress asked the National Academies to analyze the safety and security of commercial spent nuclear storage in the United States.^[32] The report listed additional steps to be taken to make dry casks less vulnerable to reduce the likelihood of releases of radioactive material from dry casks in the event of a terrorist attack. The recommendations included:

^[31] Holtec International, "The HI-STORM 100 Storage System", accessed at <http://www.holtecinternational.com/hstorm100.html> on 17 June 2007.

^[32] Safety and Security of Commercial Spent Nuclear Fuel Storage, Public Report, National Academies of Sciences, April 2005, <http://www.nap.edu/books/0309096472/html/>

- Additional surveillance could be added to dry cask storage facilities to detect and thwart ground attacks.
- Certain types of cask systems could be protected against aircraft strikes by partial earthen berms. Such berms also would deflect the blasts from vehicle bombs.
- Visual barriers could be placed around storage pads to prevent targeting individual casks by aircraft or standoff weapons. These would have to be designed so that they would not trap jet fuel in the event of an aircraft attack.
- The spacing of vertical casks on the storage pads can be changed, or spacers (shims) can be placed between the casks, to reduce the likelihood of cask-to-cask interactions in the event of an aircraft attack.
- Relatively minor changes in the design of newly manufactured casks could be made to improve their resistance to certain types of attack scenarios.”(Report, pg., 68)

High Burnup Spent Nuclear Fuel - Problems^[33]

Pilgrim, like other operating reactors, in recent years is using high burnup fuel. It is already being loaded into dry casks, yet the NRC is just starting a test to see whether the casks can handle it, with results not in until 2027. Robert Alvarez (<https://www.ips-dc.org/ips-authors/robert-alvarez/>) explains the problems in doing so. He said that:

US commercial nuclear power plants use uranium fuel that has had the percentage of its key fissionable isotope—uranium 235—increased, or enriched, from what is found in most natural uranium ore deposits. In the early decades of commercial operation, the level of enrichment allowed US nuclear power plants to operate for approximately 12 months between refueling. In recent years, however, US utilities have begun using what is called high-burnup fuel. This fuel generally contains a higher percentage of uranium 235, allowing reactor operators to effectively double the amount of time the fuel can be used, reducing the frequency of costly refueling outages.

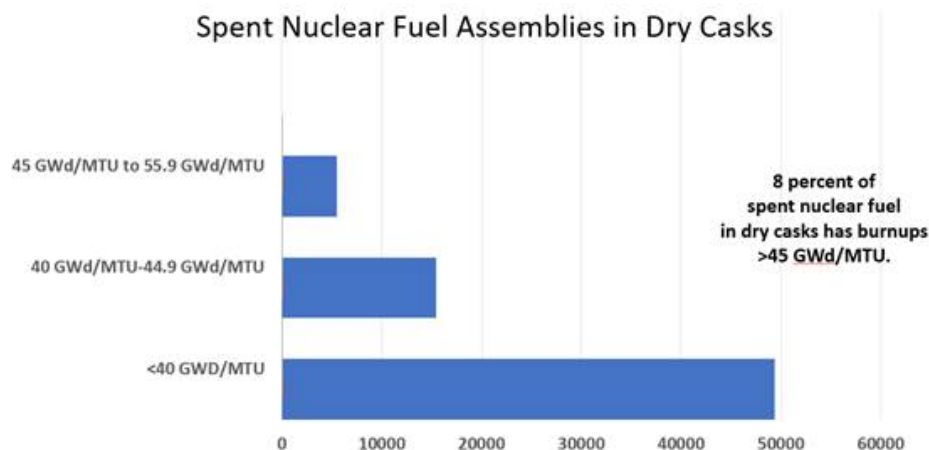
Research shows that under high-burnup conditions, cladding that of the fuel rods may not be relied upon as a key barrier to prevent the escape of radioactivity, especially during prolonged storage in the "dry casks" that are the preferred method of temporary storage for spent fuel.

High-burnup waste reduces the fuel cladding thickness and a hydrogen-based rust forms on the zirconium metal used for the cladding, which can cause the cladding to become brittle and fail. In addition, under high-burnup conditions, increased pressure between the uranium fuel pellets in a fuel assembly and the inner wall of the cladding that encloses them causes the cladding to thin and elongate. And the same research has shown that high burnup fuel temperatures make the used fuel more vulnerable to damage from handling and transport; cladding can fail when used fuel assemblies are removed from cooling pools, when they are vacuum dried, and when they are placed in storage canisters.

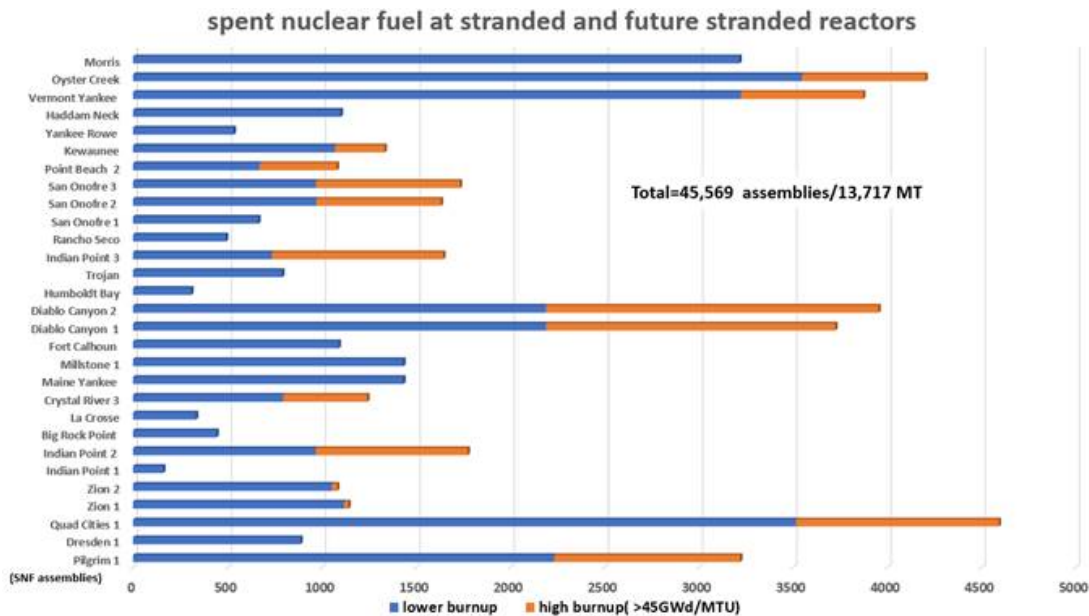
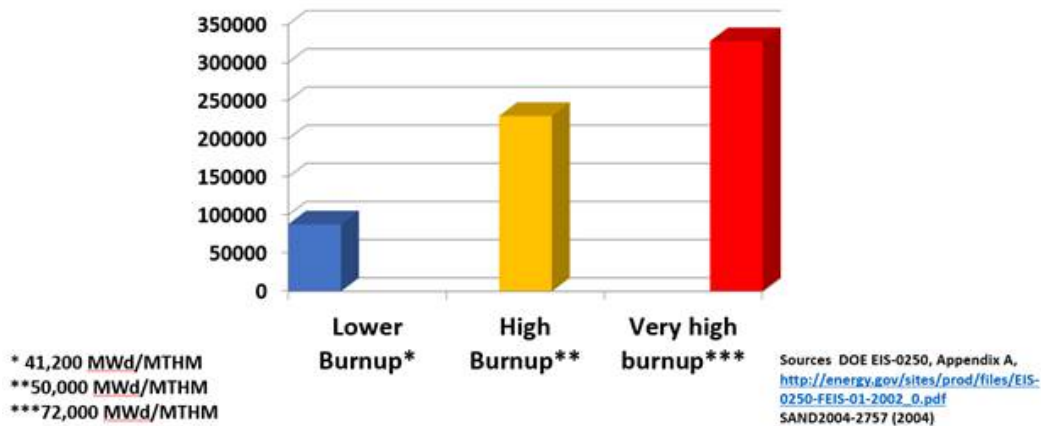
^[33] Spent Power Reactor Fuel: Pre-Disposal Issues, Robert Alvarez, Institute for policy Studies, March 3, 2017, at http://www.lasg.org/waste/Alvarez_SNF_closed_reactors_rev3_3Mar2017.pdf

High burnup spent nuclear fuel is proving to be an impediment to the safe storage and disposal of spent nuclear fuel. For more than a decade, evidence of the negative impacts on fuel cladding and pellets from high burnup has increased, while resolution of these problems remains elusive. For instance, the NRC admits:

- “There is limited data to show that the cladding of spent fuel with burnups greater than 45,000 MWd/MTU will remain undamaged during the licensing period.” There is little to no data to support dry storage and transport for spent fuel with burnups greater than 35 gigawatt days per metric ton of uranium.
- “The technical basis for the spent fuel currently being discharged (high utilization, burnup fuels) is not well established,”
- “Insufficient information is available yet on high- burnup fuels to allow reliable predictions of degradation processes during extended dry storage.”
- “What can go wrong? For example, what degradation of [high burn-up fuel] cladding might occur, leading to an unsafe condition (e.g. high burn-up fuel] cladding rupture and release of radioactive material)?
- “Experimental data over the last twenty years suggest that fuel utilizations as low as 30,000 MWd/t can present performance issues including cladding embrittlement under accident conditions as well as normal operations.



Estimated radioactivity in a U.S. spent nuclear fuel assembly



Pilgrim's spent fuel contains 35-37% high-burnup fuel.

Spent Fuel Offsite Storage

America's Hometown, Plymouth - Home for Pilgrim's Spent Fuel for decades



Spent Fuel or so-called High-Level Waste

The long term goal is to move spent fuel to a permanent repository - a storage facility located deep underground and designed for long-term safe disposal so that it will be isolated from the environment for the tens of thousands of years that it will remain toxic. The potential interim goal is consent based consolidated storage.

There is no perfect answer to storing nuclear waste that will be lethal for over 250,000 years-longer than humans have been on this earth. But should efforts to find the perfect solution stand in the way of a good solution? Pilgrim Watch believes that storing waste in 70 or so separate locations around the country is a bad plan. Reactors are located adjacent to bodies of water, needed to provide cooling to dissipate excess heat- exactly the wrong places to store nuclear waste. Some reactors are close to densely populated areas. Reactor sites are tempting terrorist targets.^[34]

How much waste are we talking about? (See: Civilian Nuclear Waste Disposal, Congressional Research Service, Mark Holt, October 23, 2017, pg., 29 <https://fas.org/sgp/crs/misc/RL33461.pdf>) Spent fuel discharged from U.S. commercial nuclear reactors is currently stored at 59 operating nuclear plant sites, 15 shutdown plant sites, and the Idaho National Laboratory. A typical large commercial nuclear reactor discharges an average of 20-30 metric tons of spent fuel per year—an average of about 2,200 metric tons annually for the entire U.S. nuclear power industry during the past two decades. DOE's Oak Ridge National Laboratory estimates that 76,436 metric tons of spent fuel was stored at U.S. nuclear plants at the end of 2016, including 6,196 metric tons at closed plant sites. The total amount of existing waste would exceed NWP's 70,000-metric-ton limit for Yucca Mountain, even without counting 7,000 metric tons of DOE spent fuel and high-level waste that had also been planned for disposal at the repository. If nuclear power continues to be generated, the amount of spent fuel stored at plant sites will continue to grow until an interim storage facility or a permanent repository can be opened— or until alternative treatment and disposal technology is developed. DOE's most recent estimates of the total amount of spent fuel from existing U.S. reactors that may eventually require disposal range from 105,000 metric tons to 130,000 metric tons. Oak Ridge National Laboratory estimates that U.S. commercial spent fuel could total 138,000 metric tons by 2056.

New storage capacity at operating nuclear plant sites or other locations will be required if DOE is unable to begin accepting waste into its disposal system for an indefinite period. Most utilities are expected to construct new dry storage capacity at reactor sites. Seventy-two licensed dry storage facilities were operating at U.S. nuclear plant and DOE sites as of August 2017.

^[34] Containment, a recent film that we recommend, looks at the problems of storage of nuclear wastes. It is available at <http://www.pbs.org/independentlens/films/containment/>

Nuclear Waste Policy Act: In 1982, the United States Congress passed the Nuclear Waste Policy Act (NWPAct), which made the U.S. Department of Energy (DOE) responsible for siting, building, and operating an underground storage facility for nuclear waste, and for taking ownership of the waste on site until it leaves the reactor site and transporting it away from reactors.

The NWPAct created a Nuclear Waste Fund to pay for the repository by charging reactor operators a fee on the waste they produced. In 2008, DOE submitted its repository license application for Yucca Mountain but shortly thereafter, in 2010, it shut the Yucca Mountain repository project and dismantled the department's Office of Civilian Radioactive Waste Management.

The Circuit Court, on requests by industry, ordered DOE on November 19, 2013, to stop collecting the nuclear waste fees altogether. The Court ruled that DOE's current waste plans were too vague to allow a reasonable estimate to be calculated. Pursuant to the court ruling, DOE stopped collecting nuclear waste fees from nuclear power generators on May 16, 2014.

In planning to restart the Yucca Mountain program, the Trump Administration announced in its FY2018 budget request that DOE would conduct a new fee adequacy assessment based on previous cost estimates for Yucca Mountain. The new assessment is intended to allow the nuclear waste fee to be reinstated in FY2020.

More than \$11 billion from the Nuclear Waste Fund had been spent on the program. The fund, established by the NWPAct to support the nuclear waste management program, collected (with interest) more than \$35 billion dollars from electricity customers. They continued to foot the bill for the program at approximately \$750 million annually until 2014, when the U.S. Court of Appeals for the D.C. Circuit ruled that DOE could not continue collection because of its 2010 termination of the Yucca Mountain repository program. The court's decision prohibits future collection of the fee until DOE complies with the Nuclear Waste Policy Act or Congress enacts an alternative used fuel management plan.

Yucca Mountain^[35]



For several years, the DOE studied a number of locations to determine their suitability, until the Congress amended the NWPAct in 1987 directing the DOE to study only Yucca Mountain, located about 80 miles northwest of Las Vegas, Nevada. Years of legal challenges and scientific studies followed.

In 2006 during the George W. Bush administration, the DOE recommended that Yucca should open and begin accepting fuel by 2017. However, opposition continued, and in 2008, presidential candidate Barack Obama promised to abandon the project. After his election, the DOE filed a 2010 motion with the NRC to withdraw its Yucca Mountain license application. It found it technically unsuitable to isolate high-level

^[35] See State of Nevada Agency for Nuclear Projects <http://www.state.nv.us/nucwaste/>; and <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/yucca-license-review.html>)

nuclear waste due to hydrology, excessive water infiltration, earthquakes, volcanoes, human intrusion and other technical issues. A number of lawsuits have been filed in response to the DOE's action.

Although no funding has been appropriated for Yucca Mountain activities since FY2010, an August 2013 ruling by the U.S. Court of Appeals for the District of Columbia ordered NRC to use available funds and resume work on its safety review of DOE's application and either approve or reject it. The NRC staff completed its safety evaluation report on Yucca Mountain on January 29, 2015, concluding that the repository would meet NRC standards after specific additional actions were taken, such as acquisition of land and water rights.

President Trump and the new Republican Congress are in favor of funding and moving forward on Yucca. The Trump administration dedicated \$120 million of its budget to Yucca. The State of Nevada opposes it and promised to mount countless legal challenges.

A bill to provide the necessary land controls for the planned Yucca Mountain repository (H.R. 3053) was ordered reported by the House Committee on Energy and Commerce on June 28, 2017. As amended by the committee, the bill would authorize DOE to store commercial waste from nuclear power plants at a nonfederal interim storage facility. It would also increase the capacity limit on the Yucca Mountain repository from 70,000 to 110,000 metric tons, in comparison with the 76,500 metric tons currently stored at U.S. nuclear plants and provide mandatory funding for specific stages of repository development.

Lawsuits: Because of the federal government's failure to meet its legal obligation under the NWPA, several reactor owners, including Entergy, have successfully sued the federal government for breaching its contracts with the companies by failing to open a facility that could accept fuel by 1998 in exchange for collecting fees for the Nuclear Waste Fund. Because of these lawsuits, the federal government has paid hundreds of millions of dollars in damages to the utilities for costs associated with storing waste at their sites long after the government was supposed to take title to it and ship it off site.

Blue Ribbon Commission: In 2010, the Obama Administration established the Blue Ribbon Commission on America's Nuclear Future (BRC) "to conduct a review of policies for managing radioactive wastes that included all alternatives for the storage, processing, and disposal of civilian and defense used nuclear fuel, high-level waste, and materials derived from nuclear activities." The Commission's final report in 2012 recommended a "consent-based" approach to siting future nuclear waste storage and disposal facilities; dismantle OCRWM and create a new agency to manage nuclear waste; and immediate work to begin development of at least one geologic repository and one consolidated storage site. Congress has tried periodically to address the BRC's recommendations, but so far without success.

After OCRWM was dismantled, responsibility for implementing the Obama Administration's nuclear waste policy was given to DOE's Office of Nuclear Energy (NE). In January 2013, DOE's NE issued a nuclear waste strategy based on the Blue-Ribbon Commission recommendations - Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste. **The strategy called for a pilot interim storage facility for spent fuel from closed nuclear reactors to open by 2021 and a larger storage facility to open by 2025. A site for a permanent underground waste repository would be selected by 2026, and the repository would open by 2048** (<https://energy.gov/em/downloads/strategy-management-and-disposal-used-nuclear-fuel-and-high-level-radioactive-waste>) DOE's projected dates are relied upon by industry in dry cask storage decisions and making cost estimations for decommissioning.

DOE issued a draft consent-based nuclear waste siting process on January 12, 2017.

Consolidated or Interim Storage

In addition to pushing to reopen the Yucca Mountain site, members of Congress with closed reactors in their states are seeking to establish a consolidated interim storage site. Energy Department-sponsored research indicates that [it may take about 15 years](#) after a license application is filed with the NRC before an interim storage site is opened at an expense of \$22.3 billion. During this time, it's likely that more reactors will be shuttered.

Waste Control Specialists (WCS), is seeking to expand its existing radioactive and hazardous waste disposal site in Andrews County, west Texas, to include storage of high-level radioactive waste from nuclear power plants across the country. If approved, 40,000 tons of irradiated fuel rods from nuclear reactors around the country could be routinely transported through major cities and farmlands.

WCS contends that privately developed spent fuel storage facility would not be bound by NWPA restrictions that prohibit DOE from building a storage facility without making progress on Yucca Mountain. A bill to explicitly authorize DOE to enter into contracts with privately owned spent fuel storage facilities (H.R. 474) was introduced January 12, 2017, by Representative Issa. It is similar to bills (H.R. 3643, H.R. 4745) introduced in the 114th Congress by Representatives Conaway and Mulvaney, respectively, but not enacted.

However, the Trump Administration's proposal to restart the Yucca Mountain project in FY2018 would provide funding for a Yucca Mountain program office, legal and technical support for the Yucca Mountain license application to NRC, and the management of millions of documents supporting the application. The Administration's request for \$10 million for interim storage would include planning for a solicitation for storage services, transportation planning, and other preparations for waste shipments

In 2016, WCS submitted its license application, but during the scoping and licensing process in April 2017, it requested to suspend review of the application due to "limited financial resources." WCS has decided to wait until the company itself is bought out by EnergySolutions, another nuclear waste disposal company based in Utah, but operating at many nuclear processing, disposal, and decommissioning sites in the US and internationally. The US Department of Justice opposed the sale because if the two merged, they would monopolize the nuclear waste disposal industry in most of the US.

Meanwhile, Areva (backed by the French government), one of WCS's original partners, pulled out and its subsidiary, TN Americas (a cask-maker), replaced it as a partner, with apparently less financial backing. NAC International, another cask-maker, is also a partner.

Holtec: The other proposed consolidated storage site is in southeast New Mexico. Holtec, partnering with the Eddy Lea Energy Alliance (ELEA), applied to the Nuclear Regulatory Commission in March 2017 to store 120,000 tons of irradiated nuclear power fuel. New Mexico's Governor Martinez supports the project. It is opposed by Senators Udall and Heinrich. Moreover, a February 2014 radioactive release from WIPP, which led to the suspension of disposal operations, could also affect public support in the state for expanded waste activities.

The consolidated storage proposals face some public opposition and uncertain legal procedures, but there is support on Capitol Hill. Led by Rep. John Shimkus (R-IL), the Energy and Commerce Committee has passed **HR3053** to amend the **Nuclear Waste Policy Act (NWPA)**. Due to President Trump's support and Republican majorities, there is widespread expectation that nuclear waste legislation will be considered in the 115th Congress. A table of nuclear waste legislation is provided by the Congressional research service at 24 <https://fas.org/sgp/crs/misc/RL33461.pdf>.

Roadblocks to Consolidated Storage: Critics say transporting highly radioactive material through densely populated areas will pose risks to residents of Texas and nearby New Mexico, and other regions of the

country. Spent nuclear fuel from power plants could be vulnerable in transit to accidents or attacks, exposing people and land to long-term radioactive poisoning, opponents of the Texas and New Mexico projects say. Public interest groups have a national campaign to “Stop Fukushima Freeways” (<http://www.nirs.org/>) to oppose consolidated sites.

Other challenges for the Texas waste facility or any other consolidated site are legal and Congressional hurdles. For the project to go forward, the Department of Energy would have to assume the title to – and liability for – the spent nuclear fuel stored at the site, but it is unclear whether the DOE can take such action on its own or needs Congressional approval. Legislation introduced last September by Rep. Mike Conaway, R-Texas, of Andrews, and another bill proposed in March by Rep. Mick Mulvaney, R-S.C., would authorize the Department of Energy to enter into fuel storage contracts with private entities that have received a Nuclear Regulatory Commission license. But neither proposal has made it past the initial introductory step.

Prospects: It will likely take decades before either a repository or interim consolidated storage site is sited and constructed. In the meantime, nuclear waste will continue to accumulate at reactor site. Implications for decommissioning: Until there is the opportunity to ship the spent fuel offsite, Pilgrim cannot decommission and release the site. Costs will continue to mount.

Reprocessing- Why it is Not the Answer to Our Spent Fuel Waste Problem

The Yucca Mountain nuclear waste repository may never happen; and Consolidated Storage is not a sure thing by any means. Now we are back to square one on the question: What are we going to do with all the radioactive waste accumulating at U.S. nuclear power reactors? Some are suggesting that we go back to re-processing - a process that takes spent nuclear fuel and dissolves it to separate the uranium and plutonium from the highly radioactive fission products. The plutonium and uranium are then recycled to make new reactor fuel, thereby reducing the amount of fresh uranium required by about 20% but also increasing the supply of weapons grade plutonium.

Pilgrim Watch does not support reprocessing because it does not solve the waste problem; rather it exacerbates it by creating numerous additional waste streams that have to be managed. It is expensive, polluting and increases nuclear weapons proliferation threats.

Expensive: Based on French and Japanese experience, the cost of producing this recycled fuel produced in reprocessing is several times that of producing fresh uranium reactor fuel. In the past, about half of France's reprocessing capacity was used to process spent fuel from foreign reactors. Because of the high cost, however, virtually all of those foreign customers have decided to follow the U.S. example and simply store their used reactor fuel.

The French reprocessing company AREVA claims that its method reduces the volume and longevity of the radioactive waste produced by nuclear power reactors. But when you take into account the additional radioactive waste streams created by reprocessing and plutonium recycling, the volume of the long-lived radioactive waste is not reduced. And most of the recycled plutonium is neither destroyed nor reused. Its makeup makes it difficult to use in existing reactors, so AREVA simply stores most of it at the reprocessing plant. Reprocessing as practiced in France amounts to an expensive way to shift France's radioactive waste problem from its reactor sites to the reprocessing plant.

Dangerous: Security: Reprocessing is enormously dangerous. The amount of radioactivity in the liquid waste stored at France's reprocessing plant is more than 100 times that released by the Chernobyl accident. That is why France's government set up anti-aircraft missile batteries around its reprocessing plant after the 9/11 attacks. Leaks: It is also dangerous due to leaks. The biggest experiment in

reprocessing was at Sellafield in Britain. In 2005, after decades of contamination and leaks into the ocean, air, and land around the reprocessing plant, Sellafield was shut down because a bigger-than-usual leak of fuel dissolved in nitric acid —some tens of thousands of gallons — was discovered. It contained enough plutonium to make about 20 nuclear bombs. Radioactive leaks are documented around Areva's reprocessing facilities in France. Nuclear Proliferation: Even more dangerous, however, is the fact that reprocessing provides access to plutonium, a nuclear weapon material. That is why the U.S. turned against it after 1974, the year India used the first plutonium separated with U.S.-provided reprocessing for a nuclear explosion. President Gerald Ford and Henry Kissinger, his secretary of State, managed to intervene before France and Germany sold reprocessing plants to South Korea, Pakistan and Brazil, all of which had secret weapons programs at the time. Japan is the only non-nuclear weapon state that still does today. If the U.S. began to reprocess again, that would legitimize another route to the bomb for nuclear weapon wannabes.

Bob Alvarez, former Department of Energy official and national expert on nuclear issues, summarized in an article he wrote in the Bulletin of Atomic Scientists:

“Reprocessing plants release about 15,000 times more radioactivity into the environment than nuclear power plants and generate wastes with high decay heat. Other efforts to build what is called a "closed fuel cycle," where waste is recycled and reused in reactors have failed for 50 years. Such failure has left about 250 tons of excess plutonium stored at reprocessing plants around the world—enough for some 30,000 nuclear weapons. It's time to accept that a once-through nuclear fuel cycle, where spent fuel is put into permanent geologic storage, is the only sensible option.” - Bulletin of Atomic Scientists, Bob Alvarez, Advice for the Blue-Ribbon Commission, March 24, 2010.

Solution: The real solution is to reduce the vulnerability and consequences of a spent fuel pool fire is by thinning the spent fuel pools; moving the spent fuel to hardened dry cask storage; and vigorously looking for a scientifically sound deep geological repository or repositories based on consent-based siting.

Spent Fuel - Selected Resources

- Pushing the storage horse with a nuclear waste cart: the spent fuel pool problem, Robert Alvarez, Bulletin of Atomic Scientists, August 2017 (<http://thebulletin.org/pushing-storage-horse-nuclear-waste-cart-spent-fuel-pool-problem11002>)
- Massachusetts Attorney General Request for Hearing ML061640065 (May 26, 2006);Improving spent fuel Storage at Nuclear Reactors, Robert Alvarez, Institute Policy Studies, Spent fuel Storage at Nuclear Reactors http://www.ips-dc.org/reports/improving_spent-fuel_storage_at_nuclear_reactors
- DOE Consent Based Siting <http://www.energy.gov/ne/consent-based-siting>
- Blue Ribbon Commission on America's Nuclear Future in 2010 <http://cybercemetery.unt.edu/archive/brc/20120620211605/http://brc.gov//>
- GAO Report (GAO-12-797) Spent Nuclear Fuel Accumulating Quantities At Commercial Nuclear Reactors Present Storage And Other Challenges, August 2012 <http://www.gao.gov/assets/600/593745.pdf>
- San Onofre Safety <http://sanonofresafety.org/>
- EA-12-051 Adjudication Proceeding <http://adams.nrc.gov/ehd/> All Power reactors EA-12-050 & EA-12-051

Current Status Waste Disposal: Civilian Nuclear Waste Disposal, Congressional Research Service, Mark Holt, October 23,2017 (<https://fas.org/sgp/crs/misc/RL33461.pdf>)

Reprocessing

- **Union of Concerned Scientists:** http://www.ucsusa.org/nuclear_power/nuclear_power_risk/nuclear_proliferation_and_terrorism/nuclear-reprocessing.html
 - **Institute of Energy Environment Research** <http://ieer.org/?s=reprocessing>
 - **Institute of Policy Studies:** http://www.ips-dc.org/articles/reprocessing_spent_nuclear_fuel_too_risky
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SECURITY

Pilgrim's (in)Security

Pilgrim is a symbolic target located in "America's Hometown." It has no defense for an air attack; and, is named among seven most vulnerable to water attack. Frequent trespassing events are reported. Security remains an issue after operations cease; Pilgrim remains vulnerable to an attack until the radioactive waste leaves the site.

The terrorist threat did not end after 9/11; acts of malice can occur at random from other parties such as the likes of the Oklahoma Bomber. Dr. Edwin Lyman, Union of Concerns Scientists, warned in testimony submitted to the US Senate:

"If a team of well-trained terrorists were to succeed in gaining forced entry to a nuclear power plant, within a matter of minutes it could do enough damage to cause a meltdown of the core and a failure of the containment structure."

Nuclear Reactors As Potential Targets Of Attack: Reactors make ideal targets because: they contain large amounts of radioactivity that could create severe impacts and their defense is "light" in a military sense. The design of reactors like Pilgrim, GE BWR Mark I's, make those reactors highly vulnerable to attack because their spent fuel pools are outside primary containment with a light roof structure overhead. In addition, Pilgrim is located in America's Hometown, making it a symbolic target.

How Secure Are Commercial Nuclear Reactors Such As Pilgrim?

Pilgrim is vulnerable to attack- while operating and after shutdown

The threat against nuclear power plants is real. According to the 9/11 Commission report, the Sept. 11, 2001 terrorists initially considered attacking a nuclear power reactor.²⁷ According to a new report "Protecting U.S. Nuclear Facilities from Terrorist Attack: Re-assessing the Current 'Design Basis Threat' Approach,"²⁸ prepared under a contract for the Pentagon by the Nuclear Proliferation Prevention Project (NPPP) at the University of Texas at Austin's LBJ School of Public Affairs finds that none of the 104 commercial nuclear power reactors in the United States is protected against a maximum credible

²⁷ <http://www.resilience.org/stories/2004-07-25/911-report-reveals-al-qaeda-ringleader-contemplated-ny-area-nuclear-power-plant-p>

²⁸ <http://sites.utexas.edu/nppp/files/2013/08/NPPP-working-paper-1-2013-Aug-15.pdf>

terrorist attack, such as the one perpetrated on September 11, 2001, nor against airplane attacks, nor even against readily available weapons such as rocket propelled grenades and 50-caliber sniper rifles.

The following table, prepared by Dr. Gordon Thompson for the Massachusetts Attorney General,²⁹ summarizes available means of attack. It shows that nuclear power plants are vulnerable.

Mode of Attack	CHARACTERISTICS	PRESENT DEFENSE
Commando-style by land	• Could involve heavy weapons/ sophisticated tactics • Attack requiring substantial planning and resources	Alarms, fences, lightly armed guards, with offsite backup
Commando-style by water	• Could involve heavy weapons/ sophisticated tactics • Could target intake canal • Attack may be planned to coordinate with a land attack	500 yard no entry zone – marked by buoys – simply, “no trespassing” signs Periodic Coast Guard surveillance by boat or plane
Land-vehicle bomb	• Readily obtainable • Highly destructive if detonated at target	Vehicle barriers at entry points to Protected Area
Anti-tank missile	• Readily obtainable • Highly destructive at point of impact	None if missile is launched from offsite
Commercial aircraft	• More difficult to obtain than pre-9/11 • Can destroy larger, softer targets	None
Explosive-laden smaller aircraft	• Readily attainable • Can destroy smaller, harder targets	None

Dr. Gordon Thompson also analyzed the impact of a shaped charge as one potential instrument of attack.^[30] The analysis shows that the cylindrical wall of the canister is about 1/2 inch (1.3 cm) thick, and could be readily penetrated by available weapons. The spent fuel assemblies inside the canister are composed of long, narrow tubes made of zirconium alloy, inside which uranium oxide fuel pellets

²⁹The Massachusetts Attorney General’s Request for a Hearing and Petition for Leave to Intervene With respect to Entergy Nuclear Operations Inc.’s Application for Renewal of the Pilgrim Nuclear Power Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Vulnerability of Pilgrim’s Spent Fuel Pool - Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants, Gordon Thompson, May 25, 2006

^[30] Gordon R. Thompson, *Environmental Impacts of Storing Spent Nuclear Fuel and High- Level Waste from Commercial Nuclear Reactors: A Critique of NRC’s Waste Confidence Decision and Environmental Impact Determination* (Cambridge, Massachusetts: Institute for Resource and Security Studies, 6 February 2009). Tables also in Declaration of 1 August 2013 by Gordon R. Thompson: Comments on the US Nuclear Regulatory commission’s Draft Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a US Mark I Boiling Water Reactor

are stacked. The walls of the tubes (the fuel cladding) are about 0.023 inch (0.6 mm) thick. Zirconium is a flammable metal.

Table 7-7: Performance of US Army Shaped Charges, M3 and M2A3

Target Material	Indicator	Type of Shaped Charge	
		M3	M2A3
Reinforced concrete	Maximum wall thickness that can be perforated	60 in	36 in
	Depth of penetration in thick walls	60 in	30 in
	Diameter of hole	• 5 in at entrance • 2 in minimum	• 3.5 in at entrance • 2 in minimum
	Depth of hole with second charge placed over first hole	84 in	45 in
Armor plate	Perforation	At least 20 in	12 in
	Average diameter of hole	2.5 in	1.5 in

Notes: (a) Data are from: Army, 1967, pp 13-15 and page 100. (b) The M2A3 charge has a mass of 12 lb, a maximum diameter of 7 in, and a total length of 15 in including the standoff ring. (c) The M3 charge has a mass of 30 lb, a maximum diameter of 9 in, a charge length of 15.5 in, and a standoff pedestal 15 in long.

Table 7-8: Types of Atmospheric Release from a Spent-Fuel-Storage Module at an ISFSI as a Result of a Potential Attack

Type of Event	Module Behavior	Relevant Instruments and Modes of Attack	Characteristics of Atmospheric Release
Type I: Vaporization	Entire module is vaporized	Module is within the fireball of a nuclear-weapon explosion	Radioactive content of module is lofted into the atmosphere and amplifies fallout from nuc. explosion

Type II: Rupture and Dispersal (Large)	• MPC and overpack are broken open • Fuel is dislodged from MPC and broken apart • Some ignition of zircaloy fuel cladding may occur, without sustained combustion	• Aerial bombing • Artillery, rockets, etc. • Effects of blast etc. outside the fireball of a nuclear weapon explosion	• Solid pieces of various sizes are scattered in vicinity • Gases and small particles form an aerial plume that travels downwind • Some release of volatile species (esp. cesium-137) if incendiary effects occur
Type III: Rupture and Dispersal (Small)	• MPC and overpack are ruptured but retain basic shape • Fuel is damaged but most rods retain basic shape • No	• Vehicle bomb • Impact by commercial aircraft • Perforation by shaped charge	• Scattering and plume formation as for Type II event, but involving smaller amounts of material • Little release of volatile species
Type IV: Rupture and Combustion	• MPC is ruptured, allowing air ingress and egress • Zircaloy fuel cladding is ignited and combustion propagates within the MPC	• Missiles with tandem warheads • Close-up use of shaped charges and incendiary devices • Thermic lance • Removal of	• Scattering and plume formation as for Type III event • Substantial release of volatile species, exceeding amounts for Type II release

One scenario for an atmospheric release from a dry cask would involve mechanically creating a comparatively small hole in the canister. This could be the result, for example, of the air blast produced by a nearby explosion, or by the impact of an aircraft or missile. If the force was sufficient to puncture the canister, it would also shake the spent fuel assemblies and damage their cladding. A hole with an equivalent diameter of 2.3 mm, radioactive gases and particles released would result in an inhalation dose (CEDE) of 6.3 rem to a person 900 m downwind from the release. Most of that dose would be attributable to release of two-millionths ($1.9\text{E-}06$) of the MPC's inventory of radioisotopes in the "fines" category.

Another scenario for an atmospheric release would involve the creation of one or more holes in a canister, with a size and position that allows ingress and egress of air. In addition, the scenario would involve the ignition of incendiary material inside the canister, causing ignition and sustained burning of the zirconium alloy cladding of the spent fuel. Heat produced by burning the cladding would release volatile radioactive material to the atmosphere. Heat from combustion of cladding would be ample to raise the temperature of adjacent fuel pellets to well above the boiling point of cesium.

Potential for Release from a Cask and Consequences: Dr. Thompson observes that: Casks are not robust in terms of its ability to withstand penetration by weapons available to sub-national groups. A

typical cask would contain 1.3 MCi of cesium-137, about half the total amount of cesium-137 released during the Chernobyl reactor accident of 1986. Most of the offsite radiation exposure from the Chernobyl accident was due to cesium-137. Thus, a fire inside an ISFSI module, as described in the preceding paragraph, could cause significant radiological harm.

Options to reduce risk: Use thick-walled metal casks, dispersal of the casks, and protection of the casks by berms or bunkers in a configuration such that pooling of aircraft fuel would not occur in the event of an aircraft impact.

Holtec has developed a design for a new ISFSI storage module that is said to be more robust against attack than present modules. The new module is the HI-STORM 100U module, which would employ the same canister used in the present Holtec modules. For most of its height, the 100U module would be underground. Holtec has described the robustness of the 100U module as follows^[31]:

"Release of radioactivity from the HI-STORM 100U by any mechanical means (crashing aircraft, missile, etc.) is virtually impossible. The only access path into the cavity for a missile is vertically downward, which is guarded by an arched, concrete-fortified steel lid weighing in excess of 10 tons. The lid design, at present configured to easily thwart a crashing aircraft, can be further buttressed to withstand more severe battlefield weapons, if required in the future for homeland security considerations. The lid is engineered to be conveniently replaceable by a later model, if the potency of threat is deemed to escalate to levels that are considered non-credible today."

Aircraft Attack

Although the NRC has required that future reactors be designed to mitigate attacks by commercial aircraft, it has not required existing reactors to make retrofits to address that threat, such as the "beamhenge" shield design.³⁰ The NRC's commercial aircraft design places tall beams around the reactor with cables strung between to break up the wings of in-coming planes.

The NRC has ignored the potentially greater rise; an air attack from a smaller, general-aviation aircraft laden with explosive material or simply a full load of fuel. The US General Accounting Office (GAO) expressed concern, in September 2003 testimony to Congress, about the potential for malicious use of general-aviation aircraft. The testimony stated:

Since September 2001, TSA [the Transportation Security Administration] has taken limited action to improve general aviation security, leaving it far more open and potentially vulnerable than commercial aviation. General aviation is vulnerable because general aviation pilots are not screened before takeoff and the contents of general aviation planes are not screened at any point. General aviation includes more than 200,000 privately owned airplanes, which are located in every state at more than 19,000 airports. Over 550 of these airports also provide commercial service. In the last 5 years, about 70 aircraft have

[31] Holtec International, "The HI-STORM 100 Storage System", accessed at <http://www.holtecinternational.com/hstorm100.html> on 17 June 2007.

³⁰ <http://committeetobridgethegap.org/beamhenge/>

been stolen from general aviation airports, indicating a potential weakness that could be exploited by terrorists.³¹

Pilgrim's spent fuel pool is especially vulnerable. The roof over the pool is light-weight. It was designed to give in a reactor core accident so as to allow the radioactive plume to extend upwards into higher elevations. It is easily penetrable. Pilgrim's outer wall is approximately 2' reinforced concrete and the wall around the spent fuel pool is 5' thick. Attack by air or land with today's readily available sophisticated weapons could penetrate the walls.

Drones: Drones pose a number of security concerns for nuclear reactors. The concern is not small. Payload drones could deliver explosives to attackers onsite. But, the main concern is that drones could enhance tactical advantage. For example, drones could distract the security guard force during a ground attack, slowing their response or causing them to be mispositioned to the advantage of the attackers; and drones could target the security cameras, motion sensors, etc. to mask ground attackers. The timelines for security force personnel to deploy and prevent attackers from successfully sabotaging key equipment are short. Anything that prevents timely and proper response by the guard force could be a problem.

Water-Based Attack

Pilgrim is on Cape Cod Bay with an extensive shoreline. Fishermen bring boats inside the 500-yard security zone. During the summer months, there is considerable pleasure boat traffic crisscrossing in front of the reactor site.

Pilgrim was one of seven nuclear plants identified as vulnerable to a ship-borne attack, in the 2013 Pentagon-contracted study "Protecting U.S. Nuclear Facilities from Terrorist Attack: Re-assessing the Current 'Design Basis Threat' Approach," referenced above.

The primary concerns regarding water-borne attacks are using a boat as a floating or submerged explosive bomb delivery vehicle targeting the reactor or other key building onsite; and/or placing a charge up the intake canal to disrupt the cooling system; and using a boat as a commando transport vehicle.

Status: There is a 500-yard "exclusion zone," simply marked by buoys – the equivalent of "no-trespassing signs." It is not made impenetrable and does not appear to be patrolled most of the time.

³¹ Gerald L. Dillingham, US General Accounting Office, testimony before the Committee on Commerce, Science and Transportation, US Senate, "Aviation Security: Progress Since September 11, 2001, and the Challenges Ahead", 9 September 2003



The Coast Guard patrols; but the Coast Guard's resources are limited. Once the patrol leaves the site, a terrorist can strike. A floating boom is, or was going to be, placed across the mouth of the intake canal but this will not stop a submerged weapon. The "exclusion" zone was breached many times – sunbathers, fishermen, kayakers, and a large Norwegian sailboat anchored inside the exclusion zone overnight, with its lights on. Entergy called the Harbormaster but not until the following morning.³²

Recommendations: Others have solved this perplexing security problem over open waters by training intelligent cameras i.e. long-range thermal video detection cameras with intelligence built into the camera or built into the video head-end at the security monitoring and control location and the use of radar and sonar. One suite of a complete waterside security system might consist of the following:

- High Performance Swimmer Detection Sonar System
- Enhanced Capability Intrusion Detection Radar System
- CCTV, Low Light TV, IR Imaging System
- Command, Control, Communications and Display System
- Long range acoustic beams
- Waterborne sea fence-as used by the Department of Defense to protect anchored ships and nuclear submarines

Land-Based Attack

Owner Controlled Area, *Protected Area*, and *Vital Area* are three key terms in nuclear plant security. Most of the *Owner Controlled Area* around a nuclear power plant can be accessed by the public without special permission. The double-fenced perimeter surrounding some, but not all, of the buildings at a nuclear plant marks the *Protected Area* that requires prior authorization and badges to enter. Additional protection is provided by limiting access to *Vital Areas* within the *Protected Area* to only those workers specially authorized to enter them.

From July 2011 to September 2014, the press reported 10 trespassing events on Pilgrim's owner-controlled area. The guard house is not manned, allowing access down the main driveway. Contrary to Entergy's policy, experts outside the NRC disagree with Entergy's and NRC's cavalier attitude. Dr. Edwin

³² And while the children were asleep... Special welcome for the Magnus, Sailboat detained, FBI called, after anchoring off Pilgrim Station, July 13, 2011, Frank Mand, Wicked Local Plymouth

Lyman, a security expert at the Union of Concerned Scientists, explained³³ that a visible security presence is vital, because it may deter terrorists from targeting a facility in the first place. Lyman said:

Part of security is to have a visible defense so that it doesn't attract adversaries who might see this kind of weakness to exploit ... the industry has really let those owner-controlled areas protections just completely erode. And they're leaving the checkpoints unmanned all the time and not doing surveillance of the area, so people can enter the owner-controlled area without any problem or detection. And I think that's a problem... I think it is kind of foolish to allow such lax controls over the owner-controlled area.

August 21, 2014, two local activists walked toward the reactor, past the unmanned guardhouse and No Trespassing sign to demonstrate to a Channel 7 crew that there was no security in effect at those areas. They passed two security guards walking up the driveway in the opposite direction. The guards took no notice. They entered the Access Control Building, observing workers entering their access codes. After approximately 20 minutes they left the building and headed back up the driveway, walking behind two security guards.³⁴

What does this incident show?



1. The picture of the Access Control building shows the two trespassers were in close proximity to the protected area. At that location, an intruder could cause serious damage with today's readily available weapons.
2. The trespassers account shows that, if they were terrorists, they could have taken down four security men, significantly cutting down the available security personnel onsite.
3. In the Access Control Building, the trespassers could have forcibly piggybacked their entrance with the employees' entrances after the employees had cleared the security screening allowing their entrance.
4. The Channel 7 news crew remained at the intersection while their SUVs remained parked 300 yards from the intersection in the southerly direction down Rocky Hill Road without any investigation by Entergy personnel into its purpose. The SUV could have been part of an attack team.

Weapons: Reactors do not have to be prepared to protect against weapons such as rocket-propelled grenades and 50-caliber sniper rifles, both readily available.

Cyber Attacks

³³ <http://dailycaller.com/2014/09/08/thedc-investigates-lax-security-at-nuclear-power-plant-outside-washington-video/>

³⁴ Watchdogs complain of lax Pilgrim security, Christine Legere, September 19, 2014 <http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20140919/NEWS/409190310>

December 15, 2017, NRC issues license amendment to Pilgrim to change the implementation date for cyber security upgrades from December 15, 2017, to December 31, 2020 – after Pilgrim is closed.

Cyberattacks Put Russian Fingers on the Switch at Power Plants, U.S. Says, New York Times, March 16, 2018

The Trump administration accused Russia on Thursday of engineering a series of cyberattacks that targeted American and European nuclear power plants and water and electric systems, and could have sabotaged or shut power plants off at will.

United States officials and private security firms saw the attacks as a signal by Moscow that it could disrupt the West's critical facilities in the event of a conflict.

They said the strikes accelerated in late 2015, at the same time the Russian interference in the American election was underway. The attackers had compromised some operators in North America and Europe by spring 2017, after President Trump was inaugurated.

In the following months, according to a [Department of Homeland Security report issued on Thursday](#), Russian hackers made their way to machines with access to critical control systems at power plants that were not identified. The hackers never went so far as to sabotage or shut down the computer systems that guide the operations of the plants.

Still, new computer screenshots released by the Department of Homeland Security on Thursday made clear that Russian state hackers had the foothold they would have needed to manipulate or shut down power plants.

- Cyberattacks- Wolf Creek NPS and Entergy Corporation
- Reactors depend on offsite power to operate their safety systems.

American officials and private cybersecurity experts uncovered a series of Russian attacks aimed at the energy, water and aviation sectors and critical manufacturing, including nuclear plants, in the United States and Europe. In its urgent report in June, the Department of Homeland Security and the F.B.I. notified operators about the attacks but stopped short of identifying Russia as the culprit.

By then, Russian spies had compromised the business networks of several American energy, water and nuclear plants, mapping out their corporate structures and computer networks.

They included that of the Wolf Creek Nuclear Operating Corporation, which runs a nuclear plant near Burlington, Kan. But in that case, and those of other nuclear operators, Russian hackers had not leapt from the company's business networks into the nuclear plant controls.

Forensic analysis suggested that Russian spies were looking for inroads — although it was not clear whether the goal was to conduct espionage or sabotage, or to trigger an explosion of some kind.

In a [report made public in October](#), Symantec noted that a Russian hacking unit “appears to be interested in both learning how energy facilities operate and also gaining access to operational systems themselves, to the extent that the group now potentially has the ability to sabotage or gain control of these systems should it decide to do so.”

[Continue reading the main story](#)

NRC's backgrounder on cyber attacks³⁵ says that "Nuclear power facilities use digital and analog systems to monitor, operate, control, and protect their plants. "Critical digital assets" that interconnect plant systems performing safety, security, and emergency preparedness functions are isolated from the Internet. This separation provides protection from many cyber threats" – but only some protection.

David Lochbaum, Union of Concerned Scientists, explained to the Cape Cod Times³⁶ that:

[T]he segregation of systems at nuclear power plants provides some protection. Their computer systems control non-safety equipment... True, hackers could cause a nuclear plant to shut down unexpectedly, but the safety systems are designed to automatically step in and perform the necessary cooling functions. Few control systems for emergency equipment are digital and therefore they are not susceptible to computer hacking."

There are multiple computer systems at a nuclear plant, and most are not connected to each other. Among those is an intranet system that contains programs and data used for scheduling work, tracking worker radiation exposure, some computer-based training, and similar activities. It also houses digital collections like blueprints.

Right now, perhaps the biggest vulnerability nuclear plants face from hackers would be getting their information on plant designs and work schedules with which to conduct a physical attack... If hackers obtained information about when a key component, like an emergency diesel generator, would be out of service, the list of equipment they'd need to sabotage to cause a bad outcome would be shortened, increasing their chances of success.

Vulnerability of Security Cameras: If there is any internet connectivity (and maybe any kind of wireless connectivity), the vulnerability can be exploited by hackers. If the cameras are reachable remotely, they may enable a malicious third party to see things (such as the typing in of a password, or the face of an operator) that should not be seen.

Beyond Nuclear showed that, "while reactor safety systems are more or less isolated from an outside cyberattack, a hack knocking out the electrical grid system would shut down power to all reactor safety systems. On-site emergency power generators are then vulnerable to insider and armed assault seeking to cause a meltdown."³⁷

Regulations (10 CFR 73.54): After the 9/11 terrorist attacks, the NRC enacted initial regulations on physical and cyber security. Those regulations include requirements to ensure that the functions of digital computers, communication systems and networks associated with safety and emergency preparedness at the plants are protected from cyberattacks.

Compliance was laid out in two phases. The first phase, completed in 2012, involved putting in place controls to protect a plant's most important digital assets. The second phase, to be completed by the end of this year (2017), entails full implementation of all the changes that were required. Pilgrim has completed the first seven "milestones" of the cyber security plan, but it has not yet completed the final

³⁵ <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/cyber-security-bg.html>

³⁶ Pilgrim seeks to skip cybersecurity rules, Cape Cod Times, Christine Legere, July 9, 2017 at <http://www.capecodtimes.com/news/20170709/pilgrim-seeks-to-skip-cybersecurity-rules>

³⁷ <http://www.beyondnuclear.org/security/2017/7/8/fbi-and-dhs-detect-cyberattack-on-us-nuclear-power-station.html>

milestone. That final milestone includes additional cyber controls, cybersecurity training for employees, incident response drills and testing.

But, despite the recent advisory of hacking attempts from the Department of Homeland Security and the FBI, Entergy filed in March 2017 a license amendment request to the NRC to change the implementation date for cyber security milestone 8 from December 15, 2017 to December 31, 2020 – after Pilgrim closed. The NRC replied that it would review the request by December 2017.³⁸ December 15, 2017. NRC issued PILGRIM NUCLEAR POWER STATION- ISSUANCE OF AMENDMENT REGARDING REQUEST TO REVISE CYBER SECURITY PLAN MILESTONE 8 COMPLETION DATE (CAC NO. MF9587; EPID L-2017-LLA-0194)³⁹ The amendment revises Pilgrim's renewed facility operating license for the Cyber Security Plan (CSP) Milestone 8 full implementation completion date, as set forth in the CSP implementation schedule, and revises the physical protection license condition. The amendment revises the CPS Milestone 8 completion date from December 15, 2017, to December 31, 2020. Pilgrim will close May 31, 2019.

Plymouth Nuclear Matters Committee, earlier analysis of security: A paper prepared for the the Plymouth Nuclear Affairs Committee⁴⁰ provided a preliminary tutorial on cybersecurity and Pilgrim. The following draws from that analysis.

Pilgrim, along with other sites, may have integrated their control systems with computer networks built from off-the-shelf commercial operating systems, such as Windows and Unix. This has made process control systems more vulnerable to attack over the internet.

NRC and licensees used to believe that the process control systems were not vulnerable to attack because: They assumed that Process Control Systems (PCS) were isolated from the internet; and PCS generally use proprietary protocols and hardware not compatible with ordinary computers and common network protocols like Ethernet and TCP/IP.

The Plymouth analysis reported on three in-cyber attack incidents at US reactors. It said:

1. In 2003, the Slammer worm began exploiting vulnerability in Microsoft SQL servers. Within ten minutes, it had infected 75,000 servers worldwide—90% of vulnerable hosts. The design of Slammer was simple; it did not write itself to the hard drive, deleted files, or obtain system control for its author. Instead, it settled in system memory and searched for other hosts to infect. Although Slammer carried no malicious payload, it still caused considerable disruption. It searched for new hosts by scanning random IP addresses. This generated a huge volume of spurious traffic, consuming bandwidth, and clogging networks. The Slammer worm also infected computer systems at the **Davis-Besse** nuclear power plant. The worm traveled from a consultant's network to the corporate network of First Energy Nuclear, the licensee for Davis-Besse, then to the process control network for the plant. The traffic generated by the worm clogged the corporate and control networks, thus *for four hours and fifty minutes, plant personnel could not access the Safety Parameter Display System (SPDS), which shows sensitive data about the reactor core collected from coolant systems, temperature sensors, and radiation detectors—these components would be the first to indicate meltdown conditions.* Although

³⁸ NRC Electronic Library, Accession Number ML17101A608

³⁹ NRC Electronic Library, Accession No. ML17290A487

⁴⁰ Cybersecurity and PNNP: A Preliminary Tutorial, Richard Grassie prepared for the Nuclear Matters Committee-Plymouth, Massachusetts, Monthly Meeting, Monday 19 January 2015

Slammer's scanning traffic did block sensors from providing digital readouts to control systems, it did not affect analog readouts on the equipment itself; plant technicians could still get reliable data from sensors by physically walking up to them and looking at them, though this process is slower than retrieving data over a network. Davis-Besse also had a firewall protecting its corporate network from the wider internet, and its configuration would have prevented a Slammer infection. However, a consultant had created a connection behind the firewall to the consultancy's office network, thereby inadvertently allowing Slammer to bypass the firewall and infect First Energy's corporate network. From there, it faced no obstacle on its way to the plant control network.

2. In 2006, a shutdown of Unit 3 at **Browns Ferry** nuclear plant occurred demonstrating that not just computers, but even critical reactor components, could be disrupted and disabled by a cyberattack. Unit 3 was manually shutdown after the failure of both reactor recirculation pumps and the condensate demineralizer controller, both of which devices were a kind of programmable logic controller (PLC) where the recirculation pumps were dependent on variable frequency drives (VFD) to modulate motor speed. Both kinds of devices have embedded microprocessors that can communicate data over Ethernet yet both devices are prone to failure in high traffic environments. The Browns Ferry control network produced more traffic than the PLC and VFD controllers could handle, and they failed.
3. In 2008, Unit 2 of the **Hatch** nuclear power plant automatically shut down after an engineer applied a software update to a single computer on the plant's business network. The computer was used to collect diagnostic data from the process control network; the update was designed to synchronize data on both networks. When the engineer rebooted the computer, the synchronization program reset the data on the control network. The control systems interpreted the reset as a sudden drop in the reactor's water reservoirs and initiated an automatic shutdown. This innocent mistake demonstrates how malicious hackers could make simple changes to a business network that end up affecting a nuclear reactor—even if they have no intent to interfere with critical systems.
4. The **Stuxnet** attack against the Iranian nuclear program demonstrates the impact that a sophisticated adversary with a detailed knowledge of process control systems can have on critical infrastructures. Stuxnet is believed to have destroyed 984 centrifuges at Iran's uranium enrichment facility in Natanz. The Stuxnet worm targeted specific PCS components used in the Iranian centrifuge cascades. The PLCs controlled the frequency converters to modulate the speed at which the centrifuges spun. Stuxnet commanded the PLCs to speed up and slow down the spinning centrifuges, destroying some of them, while sending false data to plant operators to make it appear the centrifuges were behaving normally. It was found that Stuxnet's authors may have learned about vulnerabilities in the Siemens controllers at another site in the US, thus making process control systems made up of Siemens controllers vulnerable.

The Stuxnet attack also demonstrates elements of the other cyberattack incidents mentioned above. First, it disrupted the systems that monitored physical components, like the Davis-Besse worm infection. Second, it interfered with programmable logic controllers, like the Browns Ferry data storm. Third, it relied on there being some path from ordinary office computer to process control systems, as in the Hatch automatic shutdown. Moreover, it travelled between computers on worker's thumb drives and infected components prior to arrival along the various sources along the Iranian supply chain.

The Plymouth analysis took away from these examples the following:

1. First, skeptics claim that PCS are immune from attack since they are not connected to the internet. However, the Davis-Besse incident shows that this is a misconception, even operators who try to monitor and protect every connection cannot be sure they know about all of them. Stuxnet even traveled on portable thumb drives to infect computers that were not connected to the internet.
2. Skeptics argue that PCS are immune from attack since they are different from ordinary computers, however, all four incidents demonstrate that PCS have become interoperable with ordinary computers, making them vulnerable.
3. Vulnerabilities are more complicated than both skeptics and alarmists realize. Alarmists often invoke the danger of hackers taking control of a power plant, but these incidents show how unintelligent computer viruses and even malfunctions in small devices can have big, unexpected effects. This suggests that even though nuclear facilities are vulnerable to attack, a malicious hacker would have difficulty making sure an attack works precisely as planned.
4. States have developed significant knowledge and capabilities that make cyberattacks more precise, supplementing their methods with intelligence from other sources.

The report concluded that: In the absence of a workable, reliable, and tested cybersecurity plan, PNPP has to be considered vulnerable along the same lines and in the same and possibly other manners mentioned for nuclear power plants above.

NRC Action or (in)action: All power reactor licensees must implement a cyber security plan under the NRC's cyber security regulations (10 CFR 73.54) -but not Pilgrim - leaving Pilgrim vulnerable at the time of heightened and more sophisticated threat.

NRC Force-On-Force Tests Of Security

“Force-on-force” inspections of a nuclear power plant’s security occur every three years. A team of mock terrorists test the ability of nuclear plant security forces to protect the plant from sabotage attacks that could cause a reactor meltdown or damage to spent nuclear fuel in storage pools. (Spent fuel stored in dry casks is not designated as a target for force-on-force tests: a big loophole.) These tests are said to be important because having a good security plan on paper is not a guarantee that a plant security force could effectively carry out the plan in practice.

Dr. Edwin Lyman, Union of Concerned Scientists, explained⁴¹:

The tests are intended to be as realistic as possible, but they have significant limitations. For one thing, they lack the element of surprise, which is one of the most critical tactical advantages of a real attacking force. A nuclear site must be notified well in advance of the inspection to ensure that security forces know that it is not a real attack and to give the plant management time to implement measures to maintain safety and security during the tests. However, the more notice the NRC provides, the more time and resources become available for plant management and security forces to prepare for the test, and the less representative the test will be of an actual surprise attack.

⁴¹ <http://allthingsnuclear.org/elyman/ominous-votes-by-the-nrc>; and file:///C:/Users/Mary/AppData/Local/Microsoft/Windows/INetCache/Content.Outlook/UED2GFA7/20160307-ucs-three-phase-power-backgrounder.pdf

In the force-on-force test program that was carried out in the 1990s, nuclear plants were given 6-12 months' notice, and plant managers spent hundreds of thousands of dollars getting ready. (Even so, about 50% of the plants failed the test.) But after the 9/11 attacks, when the program was revamped and strengthened, the NRC staff mandated that the notification period should not be greater than 12 weeks because "a longer notification window might not provide as accurate an assessment of typical security force readiness."

But in a paper dated (perhaps inauspiciously) September 11, 2015⁴², the staff proposed that the notification window be increased again to 9-15 months so that the inspections could be included in the regular periodic notice of all upcoming inspections that are sent to licensees, which according to the staff would "minimize disruptions to the NRC and licensees without impacting the integrity of the inspection program." And on October 6, the four sitting NRC commissioners voted unanimously to approve the change.

Does the NRC really expect an attacker to give 15 months' notice? The results of recent Force-on-force tests are not available to the public; but older reports generally show that the attack was successful.

For more on Force-on-Force tests see: <http://allthingsnuclear.org/elyman/the-nrcs-security-inspections-at-nuclear-power-plants-are-again-under-attack?>

Union of Concerned Scientists Security Recommendations What the NRC needs to do⁴³

The UCS post-Fukushima recommendations for the NRC included several items specifically addressing security issues. It said that the NRC should:

- **Revise its assumptions about terrorists' capabilities** to ensure nuclear plants are adequately protected against credible threats, and these assumptions should be reviewed by U.S. intelligence agencies.
- **Modify the way it judges force-on-force security exercises** by strengthening the assessment of a plant's "margin to failure."
- **Establish a program for licensing private security guards** that would require successful completion of a federally supervised training course and periodic recertification.
- Require new reactor designs to be **more secure against land- and water-based terrorist attacks**.
- Require reactor owners to **improve the security of existing dry cask storage facilities**.

PILGRIM - ELECTRIC RELIABILITY

⁴² <http://pbadupws.nrc.gov/docs/ML1523/ML15231A232.pdf>

⁴³ <http://www.ucsusa.org/nuclear-power/nuclear-plant-security#.WZdNbyiGO70>

Pilgrim, like all reactors, requires offsite power to operate its safety systems. Safety systems are needed until the core and spent fuel pool are emptied.

Loss of Offsite Power- Causes

Open-Phase Events: Offsite power can be lost at Pilgrim and other reactors across the country. Loss of offsite power leaves the reactor vulnerable to a so-called open-phase event in which an unbalanced voltage, such as an electrical short, could cause motors to burn out and reduce the ability of the reactor's emergency cooling system to function. If the motors burned out, backup electricity systems would be of little help. A group of NRC nuclear engineers urged NRC to order power operators to fix the problem or face mandatory shutdowns. The NRC's response was to alert nuclear power plants in a bulletin to a potential design vulnerability concerning open phases and collected feedback from operators. NRC gave reactors until the end of 2018 to permanently address the problem. The Cape Cod Times reported March 7, 2016 that Entergy spokesman Patrick Thomas O'Brien told the paper that, "given that the station will permanently shut down not later than mid-2019, additional upgrades are not planned."

Instead, Pilgrim put in place interim measures that include twice daily checks by employees of the switchyard. Entergy's "interim fix," particularly given Entergy's history⁴⁴, provides little if any comfort to the public, and should not provide any comfort to the NRC. Pilgrim Watch asked Dave Lochbaum whether visual inspections were reliable safety checks for this electrical design flaw. He responded that they were not, and cited Oconee as a concrete example.

An open phase condition was detected in December 2015 on Oconee Unit 3. Workers conducted a visual inspection of the equipment on Units 1 and 2 to ensure the same problem didn't exist there. The visual inspections did not see any problems. The following week after Unit 3 was fixed, workers conducted more thorough exams. They found an open phase condition on Unit 1. The phase consisted of six aluminum strands around a steel strand. All six aluminum strands were broken (severed). A visual inspection that cannot find severed cables is what most people call exercise. It's not a reliable nuclear safety check.

The fact the seven NRC engineers were compelled to act speaks volumes to problems with the safety culture in the NRC. To learn more and Pilgrim's response, see *The NRC Seven: Petitioning the NRC over Safety*, David Lochbaum. March 4, 2016, All Things Nuclear, Union Concerned Scientists.⁴⁵

Loss of Of Offsite Power (LOOP) also can result from: storms, act of malice, mechanical malfunctions or from the degradation of buried electric cables that bring the power from offsite into the reactor.

From 1975 to February 2015, Pilgrim lost offsite power 20 times.

⁴⁴ Entergy has demonstrated that the public cannot rely on Entergy's reports of visual inspections. February 2016, NRC discovered that a Pilgrim security officer failed to conduct assigned fire watches more than 200 times in a two-year period, in areas that required hourly checks because fire suppression systems were inoperable. The worker then falsified logs to look as though the watches had been done. In 2014, under direction from VP Mike Perito, John Babyak, the Outage Manager, was fired for forging outage paperwork, reporting that work had been done when in fact it had been not.

⁴⁵ <http://allthingsnuclear.org/dlochbaum/the-nrc-seven-petitioning-the-nrc-over-safety>

- In 1975, for example, operators were shutting down the reactor when the turbine tripped. During the ensuing in-plant electrical power transfers, blown fuses de-energized the startup and auxiliary 345 kilovolt lines, causing a loss of offsite power and an automatic reactor scram.
- During the Blizzard of 1978, the reactor was scrammed when heavy snowfall caused electrical breakers in the 345 kilovolt switchyard to flashover and trip.
- In August 1978, the reactor automatically scrammed from 100 percent power when lightning struck transmission lines causing a loss of offsite power.
- Pilgrim experienced additional LOOPs in 1979, 1982, 1983, 1986, 1987, 1989, 1991 and 1993, but not again until storm NEMO in 2013 and then twice in early 2015 due to storms JUNO and NEPTUNE.

The causes of Pilgrim's loss of power events include power supply transfers (twice), lightning strikes (four times), high winds (four times), storms (twice), ice and snow during blizzards (five times), plus a solar storm and a forest fire (once each).

Acts of Malice

The electric grid is vulnerable to terrorists - from cyberattacks to blowing up substations or transmission lines with explosives or by firing projectiles at them from a distance. The likelihood of getting caught is remote. For example, in December 2013, the press reported on a military style raid of a California Power Station.⁴⁶

The National Academy of Sciences report, Terrorism and the Electric Power Delivery System⁴⁷ concludes that the grid is inherently vulnerable because transmission lines run for hundreds of miles and many key facilities are unguarded. Terrorists could black out large segments of the United States for weeks or months by attacking the power grid and damaging hard-to-replace components that are crucial to making it work. If the lights go out, nuclear reactor safety systems cannot operate, back-up power is limited.

Pilgrim's Buried Electric Cables Not Environmentally Qualified

Risk: Most safety systems at Pilgrim, and all nuclear reactors, depend on electrical power to perform their function to prevent major accidents. Pilgrim's electric power travels over miles of submerged electric cables, many if not most of which are not qualified for a wet environment. Most electrical cables at Pilgrim have been exposed to significant moisture over the past 43 years from snow, rain, and salt. Pilgrim is located on low land directly beside Cape Cod Bay. For example, evidence of water was provided in a NRC inspection (April 2010) of 3 manholes. It reported (2) were periodically submerged or partially submerged and the other always submerged. A recent NRC report indicated an increasing trend in

⁴⁶ 'Military-Style' Raid on California Power Station Spooks U.S. BY Shane Harris December 27, 2013- See more at: <http://www.foreignpolicy.com/posts/2013/12/24/power-station-military-assault#sthash.wl8gokGt.37dBqdqW.dpuf>; <http://www.beyondnuclear.org/security/2017/7/8/fbi-and-dhs-detect-cyberattack-on-us-nuclear-power-station.html>

⁴⁷ <http://www.nap.edu/catalog/12050/terrorism-and-the-electric-power-delivery-system>

underground cable failures, and the predominant contributing factor was submergence or moisture intrusion that degraded the insulation.

In 2010, Pilgrim Watch filed a 2.206 enforcement petition asking that the NRC require Entergy to demonstrate that “all non-environmentally qualified (non-EOQ) and inaccessible cables at Pilgrim Nuclear Power Station Pilgrim are capable of performing their required function.” The NRC agreed that at least some cables at Pilgrim were not environmentally qualified and “no longer inherently reliable,” and that “cables that are not designed to operate in a submerged condition are likely to experience early failures, which can potentially result in significant safety consequences.” Nonetheless, the NRC determined that there was no real problem since Entergy had implemented a monitoring program “to the extent that there is reasonable assurance that cables subject to moisture will be adequately managed.” See NRC Adams Library, Accession No. [ML13018A457](#).

Solution to Reduce Risk: Require replacing electric cables that may be subject to submergence with ones qualified for a wet environment; or require a more robust inspection program. Currently: only cables 400 V or more are tested for cable insulation degradation and only once every six years; the inspection program is silent on the size of the sample required and what is required if deterioration is found; no baseline inspection was required before license renewal; and only one inspection each year for water collection in cable manholes and conduits.

Location of Pilgrim’s Switchyard

As shown in the picture below:

1. A hill is adjacent to the western side of the switchyard.
2. A two-story warehouse is next to the switchyard on the eastern side.
3. During a Nor’easter, the wind blows into the switch yard through a north-east facing “tunnel” between “The Plant” and the “Hill” on the left side of the picture.
4. Hills and buildings – such as the power plant – tend to draw the wind down around them.



All of these factors are reasons that storm winds swirl around in the switch yard. Large lightening arrestors in the switch yard have fallen over in the past and landed on the bus bars in the switch yard. Those lightening arrestors historically swayed and vibrated in high wind. Years ago anti-sway

attachments were made to the top of those lightening arrestors to prevent them from falling over. Are they still intact?

During a Nor'easter workers can stand near the screen house and see the waves of salt spray heading towards the switchyard. Salt spray from a northeast direction head right into the switchyard and the hills and the 2 story warehouse tend to make the salt spray and/or snow swirl around in the yard and thus cause the insulators to become coated with salt and/or ice in a storm.

Because of the location of the switchyard and the adjacent hills and buildings, Pilgrim has a long history of flashovers in the switchyard.⁴⁸ By way of contrast, the insulators on the electrical transmission towers up and over the Pine Hills do not get coated with snow and ice during a blizzard or Nor'easter and flashover.

Flashovers are not a trivial matter. Flashovers are very dangerous to workers in the yard and could cause severe burns or death. Flashovers also can cause fires.

⁴⁸ Flashover problems have a long history at Pilgrim and contributed to performance failures. For example:

1. Feb 06, 1978 (Nor'easter/Blizzard - Blizzard of 78) - The reactor automatically scrammed when *heavy snowfall* caused electrical breakers in the 345-kilovolt switchyard to flashover and trip.
2. Feb 13, 1983 (Nor'easter/Blizzard) - With the reactor shut down, there was a loss of offsite power. *High winds caused salt accumulation* on electrical equipment that led to an electrical fault and a loss of offsite power lasting about 1 minute. "Salt accumulation and electrical fault" suggests flashover.
3. Oct 30, 1991 (Nor'easter/Hurricane - Perfect Storm) - The operators shut down the reactor when a *severe storm blew* seaweed into the intake structure, clogging the circulating water pumps, and causing a loss of condenser vacuum. Weather-related loss of offsite power lasting 120 minutes. Switchyard flashover reported in LER #91-024-00.
4. Dec 13, 1992 (Nor'easter/Blizzard) - The reactor automatically scrammed on a generator load rejection caused by flashovers in the switchyard due to salt deposits during a severe storm.
5. Mar 13, 1993 (Nor'easter/Superstorm/Blizzard) - The reactor automatically scrammed on a generator load rejection caused by flashovers in the switchyard due to *wind-packed snow during blizzard conditions*.
6. Dec 19, 2008 (Nor'easter/Blizzard) - The reactor automatically scrammed when a *winter storm caused icing* in the main switchyard. Switchyard flashover reported in 1/26/15 Supplemental Inspection Report.
7. Feb 08, 2013 (Nor'easter/Blizzard - Nemo) - The reactor automatically scrammed at 9:17 pm when *a blizzard* caused offsite power to be lost. Switchyard flashover reported in 1/26/15 Supplemental Inspection Report.
8. Jan 27, 2015 (Nor'easter/Blizzard - Juno) LER 2-15-001-00 Licensee Event Report 2015-001-00, Loss of 345KV Power Resulting in Automatic Reactor Scram During Winter Storm Juno, April 1, 2015 (ML15097A259) "On Tuesday January 27, 2015, at 0402 hours, while in the process of lowering reactor power, with the reactor in the RUN mode at 52 percent core thermal power, Pilgrim Nuclear Power Station (PNPS) experienced a loss of 345KV power resulting in a load reject and an automatic reactor scram ... The root cause of the event is that the design of the PNPS switchyard does not prevent flashover when impacted by certain weather conditions experienced during severe winter storms. A modification of the switchyard is planned to address the susceptibility of the PNPS switchyard to flashovers during severe winter storms." And, a contributing cause according to the LER was failure to take corrective actions failure to take corrective actions. Failure to take corrective actions was indentified in the January 26, 2015 report and we find that this also has a long history. For example: After the February 2008 NEMO storm when there was a "weather related build up of snow and ice on a bushing..." which caused a "flashover resulting in a main generator load reject and reactor scram." R. 11. The NRC said, "Despite corrective actions to upgrade severe weather procedures to address deficiencies during a winter storm on February 8, 2013, inspectors identified that the procedure changes did not fully meet the intent of the corrective actions because there were no substantive changes to the procedure for pre-storm actions. Additionally, inspectors determined that the inadequate guidance for pre-storm actions represented a condition adverse to quality that was reasonably within Entergy's ability to identify and correct by execution of corrective actions identified in the RCE;" R. 39; See also R. 28, 29."
9. March 2018 (Nor'easter) caused Pilgrim to shutdown March 7 to replace startup transformer damaged during a switchyard flashover

Flashovers result in loss of offsite power needed both to operate Pilgrim's safety systems and to transmit power out. They also cause automatic shutdowns, i.e., scrams. Every shutdown and startup has an increased risk of error or failure of equipment. Like aircraft, accidents are most likely during takeoff and landing. Shutdowns cost money, along with adverse publicity and increased attention by the NRC and public.

CAUSE: Entergy's License Event Report⁴⁹ following the automatic scram during winter storm Juno said, "The root cause of the event is that the design of the PNPS switchyard does not prevent flashover when impacted by certain weather conditions experienced during severe winter storms. A modification of the switchyard is planned to address the susceptibility of the PNPS switchyard to flashovers during severe winter storms." We note that storms should not be limited to simply those occurring in winter.

We agree with Entergy that the design and location of the switchyard are a problem.

Switchyard Solutions

1. Switchyard Design Change: Entergy's License Event Report (LER) recognized that it was necessary to "Implement a switchyard design change to minimize switchyard flashovers during snowstorms." We would not limit the necessity to snowstorms; the design change is needed during any severe storm at any time during the year. The problem will get worse. Severe storms are predicted to be more frequent and severe due to climate change.

The design change that we recommend would be to build a large wall in front of the switch yard or build a structure over it and enclose the entire yard. It would cost money; but, as said in the foregoing, flashovers result in automatic scrams. Every shutdown and startup has a risk of error or failure of equipment as well as lost revenue to Entergy; along with adverse publicity and increased attention by the NRC and public. Second, scrams are dangerous and if a worker or several workers are severely burned or die, that properly will cost the company money too.

2. Shut-Down Reactor Prior to Severe Storms: We agree, in part, with Entergy's LER Corrective Action that said it would "Revise procedure PNPS 2.1.42 to provide additional guidance including the requirement to place the reactor in cold shutdown prior to the anticipated arrival of certain severe winter storms." Again, the reactor should be shut down prior to any severe storm irrespective of the season.

3. Corrective Actions: NRC must commit to assuring that Entergy completes corrective actions and root cause analyses in a timely manner. The Juno storm was not the first time that corrective actions were not taken. Entergy's LER admitted that "Previous cause analyses of loss of 345KV transmission lines failed to fully analyze all available weather related data to understand precisely what weather related attributes (and characteristics) were necessary to guide operators in making decisions to maneuver the plant to shutdown prior to or during snow storms with the potential for creating flashovers. As a result, Procedure 2.1.42 failed to guide operators to the correct actions necessary to preclude the automatic

⁴⁹ LER 2-15-001-00 Licensee Event Report 2015-001-00, Loss of 345KV Power Resulting in Automatic Reactor Scram During Winter Storm Juno, April 1, 2015 (ML15097A259)

scram during winter storm Juno. Previous cause analyses did not effectively use repeat events to evaluate design aspects to effectively communicate the risk of the current design.”

4. Entergy’s long history of failure to take corrective actions: For example: After the February 2008 NEMO storm when there was a “weather related build up of snow and ice on a bushing...” which caused a “flashover resulting in a main generator load reject and reactor scram.” R. 11. The NRC said, “Despite corrective actions [ordered after NEMO] to upgrade severe weather procedures to address deficiencies during a winter storm on February 8, 2013, inspectors identified that the procedure changes did not fully meet the intent of the corrective actions because there were no substantive changes to the procedure for pre-storm actions. Additionally, inspectors determined that the inadequate guidance for pre-storm actions represented a condition adverse to quality that was reasonably within Entergy’s ability to identify and correct by execution of corrective actions identified in the RCE;” R. 39; See also R. 28, 29. ”

5. Maintenance: NRC set up a required protocol for hosing the switchyard to remove salt deposits and debris; and install heaters.

Reliability of Backup Power

In the U.S., nuclear power plants are required to have emergency diesel generators with enough fuel to last 7 days, and battery capacity that can provide power further run power for another 4-8 hours (depending on the reactor) in the event the diesel generators fail.

Diesel Generators: Pilgrim has two backup air-cooled diesel generators located in a building between the main reactor and the Bay. Their oil tanks are buried so that there is risk of corrosion and in a flood surge contamination of the oil with seawater. Congressman Markey recommended legislation to increase oil supply from 7 to 14 days. There is a so-called Black Out diesel close to Rocky Hill Road. It is housed in a trailer type structure. It does not have an auto start as do the emergency diesels. We would not want to rely on that unit in a natural disaster.

Battery backup: Pilgrim has two switch trains one at elevation 3 feet and another at 37 feet to provide power for 8 hours. Congressman Markey filed legislation to increase backup power to 72 hours.

RESOURCES

Nuclear Power(less) Plants, David Lochbaum, Union Concerned Scientists, October 20, 2015 at <http://allthingsnuclear.org/dlochbaum/nuclear-powerless-plants>

Pilgrim Watch 2.206 Enforcement Petitions, NRC Electronic Library Adams Accession No. ML102020275 Federal Register Notice/Vol. 77/No. 154/Thursday, August 9, 2012. Pg., 47680

NATURAL EVENTS

After Fukushima, the NRC ordered U.S. nuclear plants to review and update their plans for addressing flooding,⁵⁰ from events such as sea level rise and storm surges, and extreme seismic activity. Entergy requested deferral of actions related to flooding and seismic reevaluations for Pilgrim in anticipation of the planned permanent shutdown of Pilgrim in mid-2019. NRC concurred, April 17, 2017. In short, the needed review and updated assessments will not happen.

Entergy's analysis of the threat posed by these external natural events and its mitigation plan, *Pilgrim Nuclear Power Station Overall Integrated Plan For Diverse And Flexible Coping Strategies (Flex) For Requirements For Mitigation Strategies For Beyond-Design-Basis External Events*, February 2013, is available on NRC's website.⁵¹

Storms

Climate change impacts: more frequent and more severe storms.

During severe winter storms with snow, ice and high winds, a likely event is loss of offsite power - power that is required to operate its safety systems. Loss of offsite power and automatic shutdowns recently occurred during February 2013 nor'easter, Nemo; and again in January 2015's nor'easter Juno.

In anticipation of loss of offsite power, Pilgrim voluntarily shut down during February 2015 winter storm Neptune. Entergy did not voluntarily shutdown during the January 4, 2018 blizzard Grayson. Loss of one of the two main power lines providing power to the site caused a scram of the reactor, instead. For a list of shutdowns caused by storms, see footnote 56. Shutdowns cost Entergy about one million dollars a day and raise questions regarding Pilgrim's reliability for supplying power to the grid.

As discussed in the section on reliability of electricity above, Nor'easters present the largest threat to Pilgrim because the reactor's switchyard faces directly towards the northeast, and a hill and building serve to channel the weather directly into the switchyard.

Flooding

Climate Change Impacts: rising sea levels, torrential rains, more frequent and severe winter storms coinciding with high tides and exceptional wave heights.

When Pilgrim was designed in the 1960's, it was estimated that the seas would rise at a slow and constant rate. But the seas are now rising much faster than they did in the past, largely due to climate change, which accelerates thermal expansion and melts glaciers and ice caps.

The United Nations' Intergovernmental Panel on Climate Change (IPCC), in October 2018 released a [new report](#) saying that the [world has about a decade left](#) if it's to limit global warming to 1.5 degrees Celsius (or 2.7 degrees Fahrenheit) above preindustrial levels. And that doing so will require a dramatic energy-use transformation. After that window closes, the world will be on path toward greater warming — and even a half-degree increase beyond that level will have dramatic consequences, bringing on periods of rising sea levels, increasing extreme weather events, worsening floods, and other impacts.

⁵⁰ <http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/flooding.html>

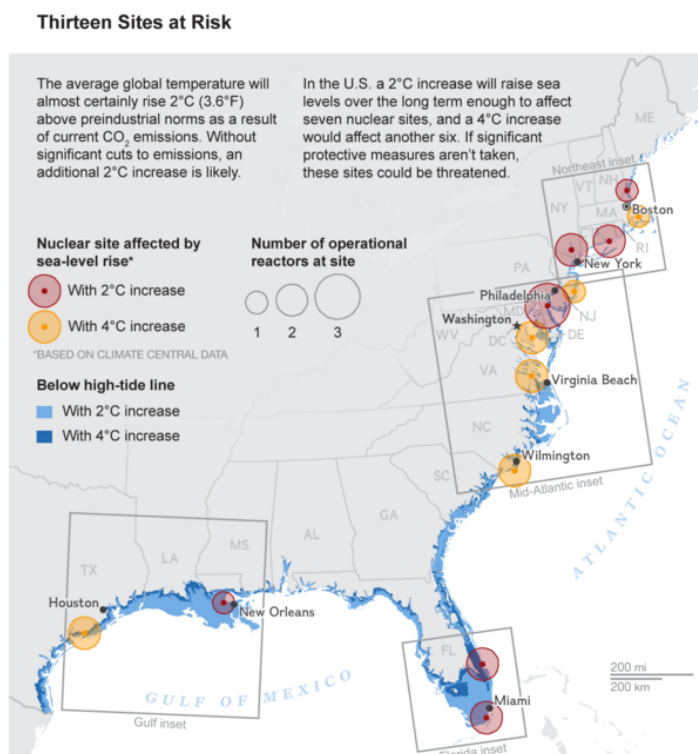
⁵¹ NRC Electronic Library, Adams, Accession Number ML13225A587

Cape Cod Bay Watch reported that:⁵²

The National Oceanographic and Atmospheric Association (NOAA) estimates a sea level rise of 3.05 feet by 2065 in the northeastern U.S. However, some believe sea levels could be rising even faster. For example, sea levels along the northeast coast rose nearly 3.9 inches in just a two year period (2009-2010) according to a [Feb 24, 2015 study](#) from the University of Arizona and NOAA. At this rate, sea levels could be more than 8 feet higher in 50 years.

Climate change has also brought torrential rains and more frequent and severe winter storms, Nor'easters. Pilgrim faces directly Northeast. The most serious threat is likely to come from surges during storms.

The National Geographic (December 16, 2015) identified Pilgrim among the 13 nuclear reactors impacted by sea-level rise and predicted that, "if significant protective measures were not taken, these sites could be threatened."⁵³



Impacts Coastal Hazards on Pilgrim Station During and After Operations Cease

Loss of Power: Flooding and severe storms can cause a loss of power. In serious conditions, flooding can damage backup generators. Without a cooling system, reactors can overheat and end up with a serious accident releasing radioactivity offsite. Also the weight of the water on the soil surface during a flood

⁵² <http://www.capecodbaywatch.org/climate-change/>

⁵³ <http://news.nationalgeographic.com/energy/2015/12/151215-as-sea-levels-rise-are-coastal-nuclear-plants-ready/>

might fail a barrier or cause other damage such as submerging and disabling electric cables that in Pilgrim's case are not environmentally qualified to be in wet conditions.

Interfere with Mitigation: In Fukushima extreme weather conditions at the site prevented workers to perform necessary mitigating actions. Severe storms and flooding could present conditions at Pilgrim so that workers could not perform their jobs.

Undermine Remediation Contaminants Onsite: Pilgrim has released radioactive and hazardous contaminants routinely and accidentally into groundwater, surface water, and soils since it began operations in 1972.⁵⁴ For example, Pilgrim opened with bad fuel and without its offgas filtration system making for a dirty site. In 1982, it blew its filters spewing radioactivity on the site and offsite. Groundwater levels increase as sea levels increase. Contamination onsite will likely continue to migrate toward Cape Cod Bay. Cleaning up the site becomes less effective the longer decommissioning takes and is exacerbated by climate change.

After shutdown, Entergy likely will opt for long-term 60 year SAFSTOR, a decommissioning process that lets Pilgrim sit idle with no clean-up and a full spent fuel pool for up to 50 or so years.

Nuclear Waste: Pilgrim's nuclear waste storage containers (Greater-than-Class C-Waste) and dry casks until the location is moved 2020-2021 are located within reach of storms, flooding and surge, sea level rise, and salt water degradation.



Don't be fooled by photos taken by Entergy. Entergy made a Topography survey for the Fukushima Pilgrim flood evaluation, May 7 2014. The survey was performed at low tide perhaps intending to show considerable distance between the reactor, LLRW containers and other structures and Cape Cod Bay. A picture is worth a thousand words or perhaps many thousands of dollars to Entergy to avoid moving/installing equipment.

Pilgrim's Flood Hazard Re-Evaluation

By letter dated March 12, 2015, the licensee for Pilgrim submitted a flood re-evaluation report⁵⁵ to the NRC to satisfy one of the agency's post-Fukushima mandates. Section 2.2.1 stated that the "minimum

⁵⁴ <http://www.capecodbaywatch.org/contamination/>

⁵⁵ Online at <http://pbadupws.nrc.gov/docs/ML1507/ML15075A082.pdf>

entrance level for areas housing SSCs [systems, structures and components] important to safety is 23 feet MSL [Mean Sea Level].”

Section 2.2 of the report stated “The PNPS design basis flood is the extreme design storm tide level of 13.5 feet MSL.” Section 2.3.1.1 explained that “the extreme design storm tide level is based on a peak storm surge of 6.6 feet coincident with a high tide of 6.9 feet MSL.” Section 2.3.1.1 further stated that “The extreme storm tide event is the only CLB [current licensing basis] flood hazard.” Section 4.1.4 repeated this statement that “The only flood hazard addressed in the CLB is an extreme storm tide level of 13.5 feet MSL resulting from either the peak storm surge from a nor’easter and an astronomical high tide, or from a maximum hurricane produced storm surge.”

Thus, according to Entergy, all flooding hazards, other than the extreme storm tide event, are outside the current licensing basis for Pilgrim. Being outside the current licensing basis means there are no applicable NRC regulatory requirements. As a direct result, there can be no associated Entergy compliance commitments.

What’s Wrong with Entergy’s and NRC’s Assessments?

Flood Hazard- Extreme Storm Surge Event

Jones River Watershed Association hired Coastal Risk Consulting to do an analysis of Entergy’s AREVA Flood Analysis Re-Evaluation Report Pilgrim Nuclear Power Station. The full report is here http://www.capecodbaywatch.org/wp-content/uploads/2012/06/CRC-PNPS-Analysis-Report_Dec2015_FINAL.pdf

The following key points are presented and explained in the report:

- Local Intense Precipitation is shown in the AREVA Report to be a primary hazard of concern that could inundate the site by as much as 2.5 feet of rainwater (AREVA p. 29). However, the AREVA analysis underestimates this risk by using outdated precipitation data and not considering future climatic conditions, which are projected to increase precipitation amounts during heavy rainfall events.
- While the storm surge analysis was robust, sea level rise over the next 50 years was understated by relying primarily on historic rates of sea level rise. This approach produces only 0.46 feet of sea level rise by 2065. However, the National Oceanographic and Atmospheric Association (NOAA) estimates sea level rise of 3.05 feet by 2065.
- Groundwater, subsidence, and erosion are not considered in the analysis, further underestimating the risks to PNPS, particularly when analyzing the combined effects of extreme storm events.
- In addition to storm surge, other factors, and mechanisms such as high tide and wave setup dramatically compound flooding. The main flaw in the Combined Flooding section of the AREVA Report relates to the limitations of the term “combined.” Of the five combined event scenarios provided in the NRC guidance document, NUREG/CR-7046, Appendix H, only one is deemed appropriate for PNPS. This conclusion disregards a wide range of possibilities for analysis with the available tools.

Pilgrim’s Heavy Rainfall Flood Hazard

The Union of Concerned Scientists 2.206 Enforcement Petition, filed June 24, 2015, showed that Table 4-1 in Pilgrim's 2015 flood hazard re-evaluation report (footnote 65) also showed that local intense precipitation events can result in flooding up to 23.5 feet MSL "at important locations on north and west sides of plant" and up to 25.2 feet MSL "at important locations on south side of plant." Such events have a negative margin to the 23 feet MSL minimum entrance elevation.

Section 2.3.1.2 of the report stated that the "water depths along the power block buildings are based on one hour precipitation rates having a probability of occurrence of 1×10^{-6} per year. The rainfall rates were developed from the National Weather Service HYDRO-35 report,⁵⁶ and the U.S. Army Corps of Engineers (USACE) Flood Hydrograph Package HEC-1 was used to develop the runoff flowrate. The duration of the PMP [probable maximum precipitation] event is one hour." Thus, the heavy rainfall hazard (encompassing local intense precipitation and probable maximum precipitation events) is neither a common occurrence nor an overly speculative threat.

Section 5.0 of the report evaluated the potential consequences from the estimated flood heights. It concluded that flooding caused by local intense precipitation is the only mechanism challenging structures, systems, and components important to safety.

Section 5.1.1 and Tables 3-1 and 4-3 indicated that the north side door to the Emergency Diesel Generator Building could be submerged to a depth of 0.6 feet. This outcome was judged acceptable based on a 1993 internal memo purporting that the doors would not fail even if flooded to a depth of 1.5 feet. That memo is not publicly available, so this claim cannot be independently evaluated. But because the NRC mandated that flooding hazards be re-evaluated, the implicit expectation is that measures relied upon to protect structures, systems and components from flooding damage would also be reassessed.

The situation in the turbine building was described in Section 5.1.1.1. The report stated that flood water could flow "to the Lower Switch Gear Room which houses SSCs important to safety." The report identified three doors (103, 105, and 311, see Figure 2 for their locations) within the turbine building preventing flood waters from damaging key equipment.

The turbine building's outer door (Door 102) was stated to be 20 feet wide by 21 feet high and designed for wind loading of approximately 0.17 pounds per square inch. The report states that the door could be flooded to a depth of 2.5 feet during a local intense precipitation event, putting a force of .0325 pounds per square inch on the door. Despite nearly double the force the door is designed to withstand, this condition was accepted in the re-evaluation report because only part of the door will be underwater. The report further reveals that a walkdown of the building showed Door 102 to be bowed inward for its bottom five feet. Because no fractures were observed, the bent door was assumed to be structurally adequate.

Table 4-1 from Pilgrim's flood hazard re-evaluation report clearly indicates, the heavy rainfall events constitute a significantly greater flooding hazard at Pilgrim than that posed by extreme storm surge. Heavy rainfall events could result in flooding levels above the entrance elevations to areas housing structures, systems, and components important to safety whereas the maximum extreme storm surge flooding levels are several feet below that elevation. Consequently, administrative measures protecting

⁵⁶ National Weather Service Office of Hydrology Technical Memoranda 35 (HYDRO-35), "Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States," June 1977. Online at http://nws.noaa.gov/oh/hdsc/PF_documents/TechnicalMemo_HYDRO35.pdf

against damage from extreme storm surges do not also protect against damage from heavy rainfall events.

Bottom line: Pilgrim's existing current licensing basis excludes heavy rainfall events despite evaluations using NRC-accepted methods that show such events to be the dominant flood hazard at Pilgrim. The 2.206 addresses this safety problem.

Seismic

After Fukushima, U.S. reactors were required to reassess their vulnerability to earthquakes, and they are given until 2017 to complete the assessment. The newly evaluated seismic risk for Pilgrim is larger than the reactor is designed to withstand. The updated seismic data shows that Pilgrim could feel the effects of earthquakes as far away as 400 miles, double the previously estimated distance.

Senators Markey and Warren in a letter to NRC Chair Macfarlane,⁵⁷ March 31, 2014, noted that, "The new seismic hazard was found to exceed the safe shutdown earthquake at the ground shaking frequencies that are most likely to threaten the equipment needed to safely shut down the reactor."

They expressed special concern about Entergy's March 10 request to the NRC asking for permission to alter some of the numbers used to model the geologic properties of the bedrock on which the Pilgrim nuclear plant sits to "prevent unjustified alarm by stakeholders when GMRS [ground motion response spectrum] results are made public."

We believe that NRC should not allow Entergy to wait until 2017 to require the company to implement mitigating measures more quickly for the reactor equipment that would be needed to safely shut down the reactors in the event of an earthquake.

Seismic Risk and Control Rods: For example, GE Hitachi issued an event report, *Failure to Include Seismic Input in Reactor Control Blade Customer Guidance* (Event Number: 46230, 09.03.10) that affects Pilgrim. It explained that engineering evaluation did not address the potential impact of a seismic event on the ability to shutdown (scram) the reactor as it relates to the channel-control blade interference issue.

Significance: Boiling Water Reactors, like Pilgrim, have control rods below the reactor core when fully withdrawn. They are inserted upwards into the reactor core. During a reactor scram, the control rods are designed to travel from the fully withdrawn position to the fully inserted position within five seconds. This means five seconds for 12 feet. The control rods are encased in channels and the control blade can rub against one or more channels during its insertion. Depending on the amount of contact, the control rod could be slowed down and take longer than five seconds to reach full insertion. If so, the nuclear chain reaction might not be stopped quick enough to prevent fuel damage during the transient/accident. The event report involved GE's failure to properly consider seismic effects in their analysis of the mechanical interference between the moving control rod blade and the outer edges of the fuel bundles.

Some reactors periodically timed the movement of control blades as a check against mechanical interference with fuel channels. These tests were not conducted during earthquakes, but their results did show margin available for seismic slowing.

If a control rod blade took the full five seconds to move normally, chances are good that any interference caused during an earthquake would further slow movement at a time when no margin for dawdling existed.

⁵⁷ Senators Markey Warren letter NRC 3.31.14 A copy of the letter to the NRC can be found [HERE](#).

Entergy's reassessment of seismic risk should include timing the movement of control blades as a check against mechanical interference with fuel channel; and base the assessment on the new understanding of maximum seismic risk estimates, not 1960 estimates when Pilgrim was built.

On May 2014 Entergy completed a seismic walkdown at Pilgrim. The NRC staff assessment of the walkdown concluded that, "... the licensee, through the implementation of the walkdown guidance activities and, in accordance with plant processes and procedures, verified the plant configuration with the current seismic licensing basis; addressed degraded, nonconforming, or unanalyzed seismic conditions; and verified the adequacy of monitoring and maintenance programs for protective features. Furthermore, the NRC staff notes that no immediate safety concerns were identified."⁵⁸

Significantly NRC failed to say that the **seismic walkdowns, like the flooding walkdowns, were based on earlier and outdated understanding of seismic risk here.**

FLAWED STRATEGY ADD SUPPLEMENTAL WATER

FLEX STRATEGIES FOR EXTREME EXTERNAL EVENTS⁵⁹

Union of Concerned Scientists critical of Pilgrim's Mitigating Strategies

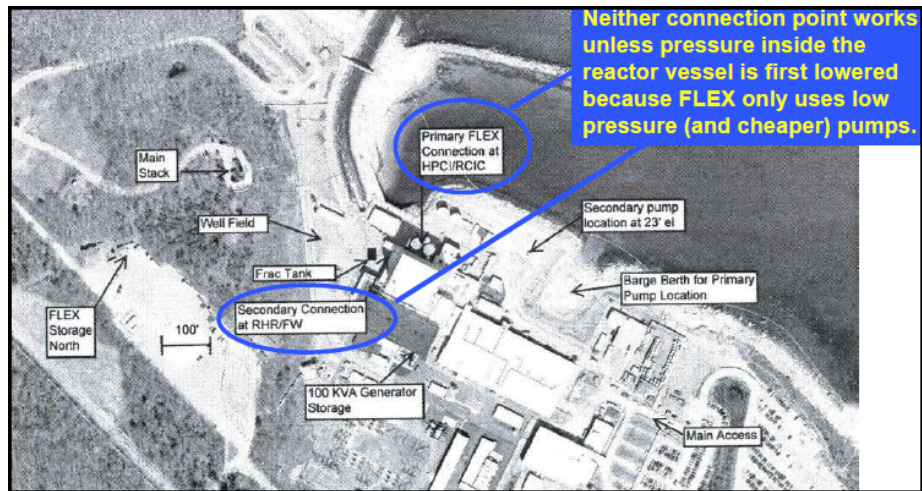
The NRC Commissioners held a meeting July 31, 2014 on the Briefing on the Status of Lessons Learned from the Fukushima Daichi Accident. David Lochbaum, Union of Concerned Scientist's Nuclear Safety Engineer, presentation focused on Pilgrim. His theme was that the original pre-Fukushima assumption that mitigating strategies that seek to provide core, containment and spent fuel cooling for an indefinite period was invalidated in Japan by Fukushima. It was replaced by the assumption that FLEX can be placed and operated in time. FLEX stands for diverse and flexible mitigation capability that comprises a variety of portable equipment that can rapidly be installed in or deployed to a nuclear facility in the event of an accident or natural disaster to provide backup electrical and cooling systems)

David Lochbaum shows why this post-Fukushima assumption may be invalid. A summary of his presentation follows and the presentation can be found here (<https://www.nrc.gov/reading-rm/doc-collections/commission/slides/2014/20140731/lochbaum-20140731.pdf>).

FLEX Pumps: Pilgrim has two spatially separated connection points provided for FLEX pumps.

⁵⁸ NRC Electronic Library ADAMS, Accession No. ML 14127A104

⁵⁹ *Pilgrim Nuclear Power Station Overall Integrated Plan for Diverse and Flexible Coping Strategies (Flex) For Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, February 2013 at NRC Electronic Library, Adams, Accession Number ML13225A587*

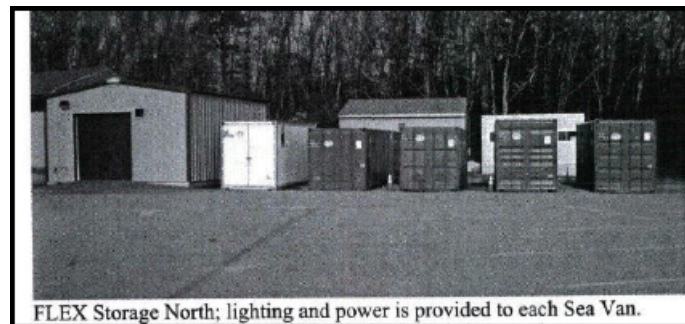


But neither of the FLEX pumps work unless pressure inside inside the reactor vessel is first lowered because FLEX only uses low pressure (and cheaper) pumps. It is nonconservative to assume that reactor vessel pressure gets lowered enough to let FLEX's low pressure pumps provide makeup flow.

The Flex storage sheds at Pilgrim are about 2,400 feet apart. It assumes that if one storage area is lost, the surviving storage area has adequate equipment. But as David Lochbaum pointed out the tornado that devastated Moore, Oklahoma flattened an area wider than 2,400 feet. A hurricane, nor-easter, blizzard or terrorist attack could do the same. Only one debris remover is provided (NRC Adams Library, Accession No. ML13063A063) and that assumes events are "tidy" and only deposit debris in designated places. So that even if there are multiple Flex equipments on site, one debris remover reduces that number to one. The NRC Technical evaluation report says that:

The single debris removal equipment identified may not be able to move debris to enable transport of equipment within the 6-9 hour time restriction for pumps and generators.⁶⁰

Flex Equipment Storage Sea Vans: Pilgrim's Flex equipment is stored in sea vans at two separate locations at the opposite extremes of the owner controlled area – approximately 18,00 feet separated. The vans are supplied with AC power for equipment heaters and lighting - one is environmentally controlled and the other has ventilation.



⁶⁰ NRC Electronic Library, ADAMS, Accession No. (ML13225A587)

What's wrong? The heaters protect the equipment before the beyond design accident, not after. NRC Bulletin 79-24 discussed events at nuclear plants where safety-related equipment was disabled by cold weather.

Instrumentation Not Covered By Post-Fukushima Orders: It is non-conservative to assume that instrumentation not covered by Post-Fukushima orders will guide operators into taking proper and timely actions.

David Lochbaum concludes (Slide 19) that Pilgrim's FLEX strategy would provide more safety if:

- FLEX employed both high and low- pressure pumps.
- Flex storage sheds were less vulnerable to common mode losses.
- Regulatory requirements governed FLEX equipment while in storage.
- Non-conservative assumptions were eliminated.

NRC Staff tell ACRS November 19, 2014 ,that they assume FLEX will not work 40% of the time;⁶¹and winter storm Juno showed Flex did not work at Pilgrim 100% of the time.

Nuclear Safety inflexibility, Disaster by Design/Safety by Intent, Dave Lochbaum, Union of Concerned Scientists, Director Nuclear Safety Project, March 15, 2016⁶² reported that:

Winter storm Juno made an unwelcome visit to the Pilgrim nuclear plant in Massachusetts in January 2015. The storm disconnected the plant from the offsite electrical grid, its normal source of power. The emergency diesel generators automatically started and supplied power to emergency equipment. Wanting to use some non-emergency equipment, workers fetched a portable air compressor from the onsite FLEX warehouse. They connected it all up and turned it on. But FLEX proved inflexible.

The portable air compressor produced air at a pressure of about 80 pounds per square inch. The equipment the workers wanted to use required an air pressure of nearly 100 pounds per square inch to operate. Instead of aiding the response, the FLEX thing turned out to be merely a noisy timewaster. (See the 52nd page of the 68 page [report by the NRC on the Pilgrim event](#).)

For the NRC's Fukushima fixes to reach their target destination, the NRC must determine why Pilgrim procured an inadequate FLEX air compressor..Too much is at stake for U.S. nuclear plants to be protected from an extreme natural event—unless an extreme natural event occurs.

⁶¹ Transcript Meeting of the Advisory Committee On Reactor Safeguards Reliability and Probabilistic Risk Assessment (PRA) Subcommittee ,Rockville, Maryland, November 19, 2014, pgs., 13,16,48-50.

⁶² <http://allthingsnuclear.org/dlochbaum/nuclear-safety-inflexibility>

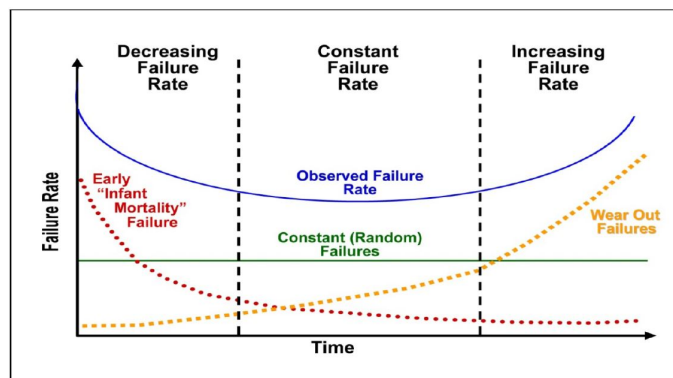
AGE RELATED DEGRADATION



Nuclear Regulatory Commission seal of approval

Pilgrim received a permit for construction in 1967. It was originally licensed for 40 years and began operations in 1972. How many appliances do you own that are over 40 years old? Pilgrim was re-licensed in 2012 to operate for an additional 20 years until 2032.

The Union of Concerned Scientists summarized how **getting old is one of the reasons safety margins can decrease or disappear over time leading to an accident.**⁶³ The bathtub curve shown below shows that wear-out failures can cause the overall failure rate to increase. As a result, considerable resources and attention need to be devoted to monitoring the condition of nuclear plant components and replacing or repairing them as required before aging degradation compromises safety margins.



But NRC's own report identified the inability of plant owners to prevent age-related failures coupled with the NRC's inability to adequately enforce the regulatory requirements being violated.

The [NRC's Operating Experience Branch released a report](#) following its review of data from 2007 to 2011. The NRC staff reviewed records such as findings by NRC inspectors and Licensee Event Reports (LERs) submitted by plant owners. Among the NRC's key findings:

⁶³ *Nuclear Plants and Nuclear Excuses: this is Getting Old*, David Lochbaum, February 25, 2014 Fission Stories #157 <http://allthingsnuclear.org/nuclear-plants-and-nuclear-excuses-this-is-getting-old/>

- “Since 2009, there is a notable increase in the number of inspection findings and LERs involving highly reliable components whose failure was attributed to age degradation after being in service for over 15 years.”
- “It is interesting to note that in more than 75 percent of the 105 datum that were reviewed, it was determined that the System, Structure, or Component (SSC) either exceeded its recommended service life or was effectively run-to-failure. Thus, it is *reasonable to question the oversight effectiveness of the baseline inspection program in this area.*”
- “About 40 percent of the 77 inspection findings were also Appendix B related findings, but only seven were cited against Criterion III, Design Control. Appendix B, Criterion III required licensees to verify or check the adequacy of design if safety-related equipment will remain in service beyond its qualified life. Thus, with *greater than two-thirds of findings and events involving SSCs left in service well beyond expected service life, it is reasonable to question why NRC oversight programs are not more focused on aging management of active SSCs.*”

That the NRC was inadequately enforcing regulatory requirements was documented in an [audit report released on October 28, 2013, by the NRC’s Office of the Inspector General \(OIG\)](#). OIG audited the NRC’s oversight of active component aging. (Active components are valves, motors, fans, electrical relays, etc., whereas passive components include pipes, supports, and tanks.)

OIG’s conclusion was critical:

The NRC’s approach for oversight of licensee’s management of active component aging is not focused or coordinated. This has occurred because NRC has not conducted a systematic evaluation of program needs for overseeing licensees’ aging management for active components since the establishment of the Reactor Oversight Process (ROP) in 2000 and does not have mechanisms for systematic and continual monitoring, collecting, and trending of age-related data for active components. Consequently, NRC cannot be fully assured that it is effectively overseeing licensees’ management of aging active components.

Pilgrim is old and has been headed in a downward spiral. For example:

In 2013, Pilgrim had 20 event reports to the NRC - more than any other plant in the country. About half of the reports were due to equipment problems. The shutdowns and required event reports are clear signs that Entergy is not making the necessary investments in personnel (laid off workers) and maintenance that are needed to safely run this old reactor. Why? Because in Massachusetts’ deregulated market, Pilgrim cannot compete with cheaper sources of electricity, mainly natural gas. Hopefully NRC actually will keep a close eye on Pilgrim because we are at increased risk if aging safety components simply are ignored.

In 2016, the downward trend continued.

January: Phase A inspection finds water leak in core spray system that helps cool reactor was known but went unaddressed for nearly a year. Inspectors criticize operators for ongoing failure to follow through with repairs.

February: * Reactor lowered to half power after water leak found in main condenser, which holds thousands of tubes to circulate water from Cape Cod Bay to cool turbine. * NRC investigation finds a security officer at plant skipped more than 200 assigned fire watches between June 2012 and June 2014.

April: Bearings break down on one of the pumps that draw millions of gallons of seawater from Cape Cod Bay to cool plant systems. Operators knew of problem with bearings since Nov. 7.

May: * Rapid power down to 50 percent after shear pins break on traveling screens that prevent seaweed from clogging cooling water system. Wrong pins had been installed during reactor refueling in 2015. The pins had been too small, capable of holding about 3,877 pounds. Correct pins can hold 8,050 pounds.

* Phase B inspection finds corroded supports for piping that distributes cooling water to reactor and other plant systems. Finding relates to problem identification and resolution, since corrosion of supports found in October 2015. Some were replaced and repaired; others were not. * A boron panel designed to absorb neutrons and prevent a nuclear reaction called fission from occurring in the fuel pool is found to have deteriorated. Fuel located near the defective panel is moved to another section of pool. Long-standing problem; thinning pool is real solution.

June: Pilgrim operating at 30 percent power crews worked to repair a seawater leak.

July: Electrical relays relied on to shut safety valves that prevent radioactive release during an accident found to have exceeded their shelf life by 12 years.

August: Four-day reactor shutdown after large valve on main isolation valve system fails to close quickly enough during testing. Problem with same valve system caused shutdown in August 2015.

September: * Manual reactor scram due to high reactor water level -faulty feedwater regulator valve.

* Release of hydrogen gas into the atmosphere above allowable levels. Entergy did not notify the Plymouth or Duxbury Fire Department of the hydrogen release as it is required to do and filed a false report saying that they had followed the notification protocol. * A mechanical malfunction of the turning gear that helps spin the turbine and maintain it in proper balance forced a shutdown making eighth day offline.

NRC found in its December 2016 Preliminary Pilgrim Inspection Report that Pilgrim's "broken equipment... never gets properly fixed."

Decommissioning: When Pilgrim is decommissioned an autopsy should be performed to provide lessons learned on aging to apply to other operating reactors of similar design.

HUMAN ERROR



Three Mile Island was caused by human error. President Carter’s Kemeny Commission’s October 1979 report said that:

The fundamental problems are people-related problems...wherever we looked, we found problems with the human beings who operate the plant, with the management that runs the key organization, and with the agency that is charged with assuring the safety of the nuclear power plants... the failure of the organization to learn the proper lessons from previous incidents...we are convinced that an accident like Three Mile Island was eventually inevitable.”⁶⁴

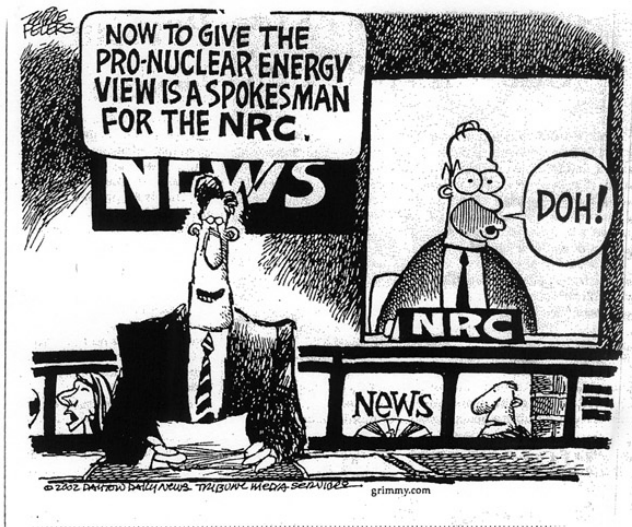
The human factor played into the **Chernobyl** and **Fukushima** disasters also. Human error is likely to increase as qualified workers with site specific experience retire; and worker morale lowers due to layoffs caused by industry’s efforts to save money in a competitive electric market. For example, the NRC observed that Pilgrim’s response to winter storm Juno’s loss of offsite power was complicated by equipment failures and operator errors.⁶⁵

In 2011 for example, Pilgrim had a near miss caused by operator errors. A “near miss” raises the risk of damage to the reactor core and thus to the safety of workers and the public. When restarting the reactor after a refueling outage, workers overreacted to indications that the water inside the reactor was heating up too rapidly, and lost control of the reactor. The plant’s safety systems automatically kicked in and shut down the reactor. But what if the safety systems had malfunctioned?

NRC OVERSIGHT (OVERLOOK) POLICY

⁶⁴ David Lochbaum, Ed Lyman, Susan Stranahan, Fukushima: The Story of a Nuclear Disaster, 2014, New Press, pg., 150.

⁶⁵ Pilgrim Nuclear Power Station – NRC Special Inspection Report 05000293/2015007; and Preliminary White Finding, May 27, 2015



According to the Nuclear Regulatory Commission's website "The U.S. Nuclear Regulatory Commission (NRC) was created as an independent agency by Congress in 1974 to ensure the safe use of radioactive materials for beneficial civilian purposes while protecting people and the environment. The NRC regulates commercial nuclear power plants and other uses of nuclear materials. Despite its purported role to ensure safe operations of nuclear reactors, the public recognizes that this is not so leading many to refer to the NRC as "Nobody Really Cares."

- The GAO in 1997 concluded that the NRC lacked criteria to shut down an unsafe reactor; it does not have a definition of safety. It was true then and remains true two decades later.
- NRC's Office of the Inspector General (OIG) surveyed the safety culture and climate within NRC. It showed a worse safety culture than found at some of the worst performing reactors. It reported too many NRC staff feared reprisal from reporting safety problems.
- The NRC does not enforce its own regulations; it allows industry to write its rules and guidance in order to protect industry's bottomline, not public safety.

NRC - No Definition of Safety

The GAO 1997 Report⁶⁶ said that "Determining the safety of plants is difficult because NRC does not precisely define safety." NRC claims to be a safety regulator, yet literally and figuratively doesn't even know the meaning of the word safety. To be clear: the NRC will not shut down Pilgrim or any operating reactor merely because it is unsafe. The NRC has no definition for unsafe; Over the past 30 years, it has never found that any reactor was unsafe.

NRC Lacks a Safety Culture⁶⁷

⁶⁶ GAO/RCED-97-145 NRC's Oversight of Nuclear Power Plants

⁶⁷ The NRC and Nuclear Safety Culture: Do as I say, Not as I do, Dave Lochbaum, February 27, 2017 (<http://allthingsnuclear.org/dlochbaum/the-nrc-and-nuclear-safety-culture-do-as-i-say-not-as-i-do>)

David Lochbaum, Union of Concerned Scientists reported that:

NRC itself has nuclear safety culture problems. The NRC's Office of the Inspector General (OIG) has surveyed the safety culture and climate within the NRC every three years for the past two decades. The latest survey was conducted during 2015 (Adams NRC Electronic Library, Accession Number ML16106A012) released in March 2016. Figure 1 from the OIG's 2015 survey along with data from the annual Federal Employee Viewpoint Surveys and other sources show safety culture problems as bad as—if not considerably worse—than the worst safety culture problems identified at Millstone, Davis-Besse, and yes, even the TVA reactors.

Why would the NRC take steps to remedy safety culture problems at nuclear plants yet have taken no steps to remedy its own safety culture problems? The answer is the same as to the question of why the plant owners failed to take steps to correct safety culture problems before the NRC intervened—they did not perceive the problems to exist. NRC's senior management does not perceive the safety culture within the agency to need remediation.

NRC's 2016-2017 Special Inspection of Pilgrim Station concluded that Pilgrim's main problem is a lack of safety culture. The NRC intervened to enable Entergy to see, and then hopefully fix, their safety culture problems. Someone needs to intervene to help NRC senior management see the agency's safety culture problem, so they can take the corrective measures they have asked Pilgrim to take.

*Safety Culture is not Possible without Regulatory Compliance*⁶⁸ by Paul Blanch examines, "[T]he actions, and inactions, of the Nuclear Regulatory Commission (NRC), Nuclear Energy Institute (NEI), and nuclear plant owners, (that) have led to financial considerations taking priority over nuclear safety. The current focus on nuclear safety via what the industry and its regulator call "safety culture," unless redefined and clarified, is a dead end. To truly achieve nuclear safety, "regulatory compliance and enforcement" must be the frame used to gauge Nuclear Safety Culture."

NRC Does Not Enforce its Own Regulations:⁶⁹

UCS gave an example in 2017 of seven NRC employees who petitioned the NRC to take enforcement action against plant owners for violating regulatory requirements, General Design Criterion 17 relating to electricity. This safety problem affects all reactors except Seabrook. The NRC Staff said that it intends to enforce the regulation **unless plant owners violate the current regulation**. In that case, the NRC staff plans to **grant enforcement discretion** to allow reactors with inoperable electric power systems to continue making profits. Profit once again placed ahead, way ahead, of public safety.

Although NRC says its regulations are developed to protect public health and safety, the NRC allows plant owners to comply with these regulations, or not to comply with them, whichever is most convenient for the industry; that's the bottom-line.

⁶⁸ http://www.ectoxic.org/Safety_Culture_Report_by_Blanch_9_13.pdf)

⁶⁹ See <http://allthingsnuclear.org/dlochbaum/update-on-the-nrc-seven-petitioning-the-nrc-over-safety>

Pilgrim has too many recent examples of non-compliance. NRC has given Entergy a pass on implementing safety fixes for its last 2-3 years of operations, assuming (absent facts) nothing can happen, so why make them pay.

- After Fukushima, NRC established a Task Force and issued some regulations (Orders) based on lessons learned. The regulations had specific compliance dates, some before Pilgrim is scheduled to close. In 2019, Entergy asked NRC to postpone implementation of the Order to make its direct torus vent severe accident capable until after they close in 2019; and then, Entergy said it would ask NRC for relief from the Order. NRC complied⁷⁰ saving industry money but placing the public at risk.
- The threat of a cyber-attack on nuclear reactors is real. NRC issued regulations to deal with the threat. Once again, Pilgrim was excused from complying because it was closing in 2019.
- Rules require that if a timely evacuation is not possible, operations must cease. Yet during severe Nor'easters when the probability of a problem at the reactor increases and NRC knew timely evacuation was not possible, NRC did not order Pilgrim closed. An example is the March 2, 2018, and January 28, 2015 (Juno) severe Nor'easters.

In conclusion, NRC is not consistently enforcing its own regulations; and allowing industry to essentially write any new regulations or substituting industry written guidance for regulation. The newest twist is to allow industry to prioritize which regulations that they will follow.⁷¹ Saving industry money is the driving factor, not public safety. NRC, like industry, believes that an accident cannot happen here. This is the core problem.

Case Study: Pilgrim not shut down in 2017 after 10 to 15 violations of federal safety regulations.

Nuclear Safety Performance at Pilgrim, DAVE LOCHBAUM, DIRECTOR, NUCLEAR SAFETY PROJECT | FEBRUARY 6, 2017, 6:00 AM EDT <http://allthingsnuclear.org/dlochbaum/nuclear-safety-performance-at-pilgrim> EXCERPTS

The Nuclear Regulatory Commission (NRC) held a public meeting on Tuesday, January 31, 2017, in Plymouth, Massachusetts. The elected officials asked the NRC to conduct a public meeting to discuss the contents of an email from the leader of an NRC inspection team at Pilgrim to others within the agency regarding the results from the first week's efforts. An NRC staffer forwarded this email to others within the agency, and inadvertently to a local organization. The contents of the leaked email generated considerable attention.

[T]he NRC panel of Dan Dorman, the Regional Administrator for NRC's Region I, Bill Dean, the NRC's Director of the Office of Nuclear Reactor Regulation, Raymond Lorson, the

⁷⁰ Pilgrim Nuclear Power Station - Relaxation of The Schedule Requirements For Order Ea-13-109: Order Modifying Licenses With Regard To Reliable Hardened Containment Vents Capable Of Operation Under Severe Accident Conditions, April 2017, NRC Adams Library, Accession No. ML17031A050

⁷¹ Nuclear plant operators keep trying to reduce regulatory burden , Mathew Bandyk, SNL, <https://www.snl.com/Interactivex/article.aspx?CdlId=A-32309727-11824>

Director of the Division of Reactor Safety in Region I, and Don Jackson, the leader of the NRC inspection team at Pilgrim and author of the email (ran the meeting).

Don went through the leaked email, which he had written, updating the audience on each issue and supplementing the email with results from the team's efforts since that initial week. I had expected the NRC to talk about what systems, components, and administrative processes the inspection team examined, but anticipated the NRC would not discuss results until the team's report was approved and publicly released. But Don candidly provided the results, too. More than once, Don explained that the team identified an apparent violation of NRC's regulations—in fact, he stated that 10 to 15 potential violations had been identified.

After the NRC panel finished their remarks, the meeting moved to comments and questions from the public. I was the third member of the audience to speak to the NRC. I asked the NRC four questions. After I posed the four questions, the NRC panel answered. My questions and the NRC's answers:

UCS Question #1

The NRC's 20-member inspection team covered a lot of ground, but still examined a small fraction of the safety systems at Pilgrim. Based on the large number of safety violations in the small sample the team examined, what assurance can the NRC provide about the state of most safety systems the team did not examine?

NRC Answer: The NRC's reactor oversight process (ROP) features periodic inspections of safety systems at Pilgrim with the team inspection being supplemental to those activities. If there were problems in those other safety systems, the periodic inspections would reveal them.

UCS Response: Don Jackson described his team identifying 10 to 15 apparent violations of federal safety regulations in the small sample of safety systems they examined violations that apparently were NOT revealed previously by the ROP's periodic inspection efforts. Those routine inspection efforts failed to identify violations among the small sample, strongly suggesting that the routine inspection efforts also fail to find violations in the larger sample.

UCS Question #2

Don Jackson explained that the text in his email about the staff at Pilgrim appearing overwhelmed or shocked referred to their reaction to the arrival of the NRC's 20-member inspection team. Does the NRC believe that this staff might also be overwhelmed or shocked in response to an accident?

NRC Answer: Don Jackson explained that his email comments referred primarily to the plant's support staff (e.g., engineers, maintenance workers, etc.) rather than about the control room operators. Don said that his assessment of the operators at Pilgrim during their duties in the control room and during exercises on the control room simulator gave him complete confidence that the operators would be able to successfully respond to an accident.

UCS Response: Even if Don's assessment is correct (and the *operators losing control of the reactor* during a routine startup causing it to automatically shut down to avoid fuel damage,

the operators *mis-operating numerous safety components* following Winter Storm Juno and the operators *not receiving proper training* on the use of the high pressure coolant injection system leaves room for doubt), it is incomplete. The response to an accident involves considerably more than the handful of operators on duty at the time. to staff the Technical Support Center, the Operations Support Center, and the Emergency Operations Facility. The work force freaking out because 20 NRC inspectors arrive on site—by an appointment made weeks in advance—suggests that work force could be equally stressed out responding to an unannounced accident.

UCS Question #3

Dan Dorman mentioned the NRC planned to conduct another public meeting in late March about this inspection and to release the team's final report in mid-April. Would it be possible for the NRC to issue the final report before the public meeting to allow the public to review the report and participate meaningfully in the meeting?

NRC Answer: Don Jackson mentioned that the report for a recent team inspection at another nuclear plant was over 350 pages due to all the information it contained. He said it would take sustained effort for the report by the team for their inspection at Pilgrim to be issued by mid-April, with no real opportunity for putting it out sooner.

UCS Response: There are two items both under full control of the NRC—the public meeting and the team inspection report. I have no reason to doubt Don's word that mid-April is the soonest that the report can be released. I have every reason to doubt why the NRC must hold the public meeting in late March. The NRC could conduct the public meeting in late April, or early May, or mid-May, or late-May, or early June, or any time after they release the team's report. The only reason for the NRC to conduct a public meeting about a non-existent report is because that's the way they prefer to do it.

UCS Question #4

Audience members for this meeting are given three strikes before they are out of the meeting. How many strikes has the NRC given Pilgrim before it is out?

NRC Answer: Bill Dean began to answer the question, but Dan Dorman interrupted him. Dan labeled the question rhetorical and directed Brett to proceed with the next speaker.

UCS Response: I appreciate NRC bringing back Bert the turtle with this Duck and Cover gimmick. To be sure, I'd have better appreciated the NRC's explanation why audience members get dragged out of the room after three strikes while Pilgrim does not get shut down after 10 to 15 violations of federal safety regulations. But this is America where everyone has the right to chicken out. My apologies if I put the NRC in a foul mood.

To Be (Shut Down) or Not to Be (Shut Down)

The recurring theme during the meeting was whether the known performance problems warranted the shutdown of Pilgrim (either permanently or until the problem backlog was eliminated) or if Pilgrim could continue operating without exposing the community to undue risk.

Best I could tell, the meeting did not change any participant's viewpoint. If one entered the room believing Pilgrim was troubled but sufficiently safe, one left the room with this belief

intact. If one entered the room feeling Pilgrim's problems posed too great a hazard, one probably left the room with even stronger convictions.

The meeting was somewhat like a court trial in that two reasonably supported but entirely opposite arguments were presented. The meeting was unlike a court trial in that instead of a jury, only time may decide which argument is right.

The Argument for Pilgrim Continuing to Operate

The team inspection led by Don Jackson is a direct result of an increasing number of problems at Pilgrim that caused the NRC to drop its performance assessment from Column 1 of the ROP's *Action Matrix* into Column 2, 3 and eventually 4. The NRC developed the ROP in the late 1990s in response to high-profile troubled nuclear plants like Millstone, Salem, and Cooper.

The Action Matrix has five columns. A reactor with performance so bad that the NRC places it into Action Matrix Column 5 cannot operate until the NRC is satisfied enough of the problems have been corrected to permit restart.

Dan Dorman and Don Jackson tried to explain during the meeting that it was not the number of problems that determined placement into Column 5, it was the severity of the problems that mattered. They said several times that the 10 to 15 apparent violations identified by the team reinforced the NRC's determination that Pilgrim was a Column 4 performer but did not cause them to feel movement into Column 5 was warranted.

Pilgrim got into Column 4 as the result of several violations identified by NRC inspectors that were classified as White, the second least severe classification in the NRC's Green, White, Yellow, and Red system. The data suggests performance shortcomings warranting regulatory attention, but it doesn't suggest a trip to nuclear jail.

The Argument for Pilgrim Shutting Down

The NRC panelists stated several times during the meeting that they did not see any immediate safety concern that required Pilgrim to be shut down. Those assurances would be more meaningful and credible had the panelists or their NRC colleagues periodically seen an immediate safety concern, even from a distance.

The last time the NRC saw an immediate safety concern and ordered an operating reactor to shut down was *March 31, 1987* when the agency ordered the Unit 2 and 3 reactors at the Peach Bottom nuclear plant in Pennsylvania to be shut down (the Unit 1 reactor had already been permanently shut down). Dan Dorman and Ray Lorson did not join the NRC staff until 1991. Don Jackson did not come to the NRC until 2003. Of the four NRC panelists, only Bill Dean was with the agency the last time an immediate safety concern was spotted. Yet there have been times since 1987 when immediate safety concerns have existed:

Davis-Besse Safety Blind spot

In the fall of 2001, the NRC staff drafted an order that would require the Davis-Besse nuclear plant to be shut down. To justify the order, the NRC staff assembled the strongest circumstantial case one could hope to build that an operating reactor was unsafe. The NRC staff evaluated the reactor against five criteria in Regulatory Guide 1.174 (RG 1.174). All five criteria had to be satisfied for a reactor to be considered safe. The NRC staff determined that one criterion was not met, and the other four criteria were most likely not met. Absent

dead bodies or mushroom clouds, you cannot build a stronger case that an operating reactor is unsafe.

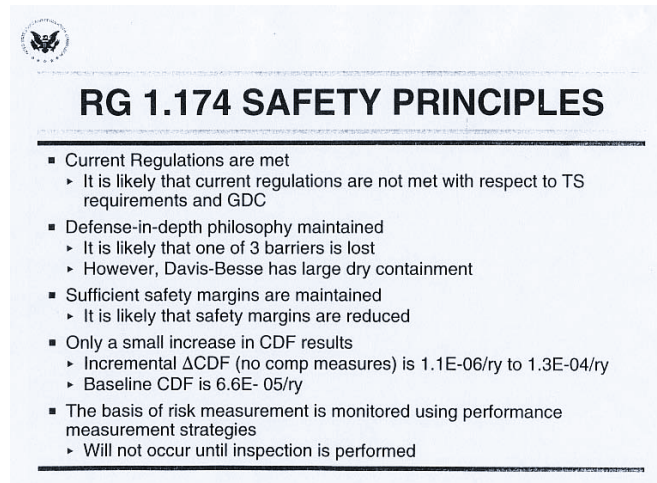


Fig. 4 (Source: Nuclear Regulatory Commission)

But NRC senior managers shelved the order and allowed Davis-Besse to continue operating. When the reactor finally shut down, workers discovered the reactor was less safe than the NRC staff had feared. According to the NRC, Davis-Besse came closer to a meltdown than any reactor since the Three Mile Island accident in March 1979 (much closer than Peach Bottom ventured in March 1987).

Worse still, when interviewed by the NRC's Office of the Inspector General, the NRC senior managers stated, under oath, stood behind their decision. They claimed they needed absolute proof that an operating reactor was unsafe before they would order it shut down. Somehow, failing to meet five of five safety principles does not constitute absolute proof to the NRC. Perhaps not meeting eight or nine out of five safety principles would suffice.

Oconee Safety Blind spot

In June 2010, the NRC issued a confirmatory action letter (CAL) to the owner of the Oconee nuclear plant in South Carolina. The CAL required that the owner take fifteen steps to reduce risk of failure at the upriver Jocassee Dam (which was also owned by Oconee's owner) and to lessen the flooding vulnerability at Oconee should the dam fail.

The NRC staff discovered that the failure rate for the Jocassee Dam was as high as other hazards that Oconee was protected against. Thus, failure of the dam could not be dismissed as incredible or overly speculative.

The NRC staff further estimated that if the Jocassee Dam failed, flooding at the Oconee site created a 100 percent chance of causing all three operating reactors to melt down, all cooling of the spent fuel pools to be lost, and all three reactor containments to fail.

The high risk of flooding causing three operating reactors to melt down prompted the NRC to issue the CAL to Oconee's owner nine months before flooding caused three operating reactors at Fukushima to melt down.

The hazard was real enough to cause NRC to require the owner to take steps to lower the risk, but not real enough to warrant the reactors to shut down until the risk was better managed.

Most galling is the fact that the NRC withheld information about this hazard from the public. Their June 2010 CAL was issued in secret. When the NRC conducted their annual public meeting in the Oconee community in April 2011—about six weeks after flooding melted three operating reactors at Fukushima—they said nothing about the CAL being issued to better manage flooding vulnerabilities at Oconee. The public cannot trust an agency that withholds relevant information from them.

It may be true that the NRC would order an operating reactor to be shut down if it saw an immediate safety concern. But it's been nearly thirty years since the NRC noticed an immediate safety concern at an operating reactor. Since then, the NRC has noticed very serious safety problems at Davis-Besse and Oconee yet allowed those reactors to continue operating.

The Davis-Besse and Oconee cases occurred after the NRC adopted the ROP and its Action Matrix. None of the safety problems that led to the NRC staff drafting a shutdown order for Davis-Besse or issuing a CAL for flood protection problems at Oconee were considered in the ROP. These safety problems were entirely invisible as far as the Action Matrix was concerned.

The NRC should not rely on a safety yardstick that ignores significant safety issues.

UCS's Argument about Pilgrim

It is entirely reasonable for the community around Pilgrim to have anxiety about the plant's known performance problems. The NRC has demonstrated that it will jettison safety standards to avoid shutting down a reactor, even when the NRC itself has repeatedly said that the reactor doesn't measure up. The NRC also has not recently demonstrated an ability to spot immediate safety concerns. Shutting down Pilgrim would lessen public anxiety.

The public should have trust and confidence in the NRC to protect them from Pilgrim's problems, but it does not. The NRC has not done much to warrant such trust and confidence by the NRC. If public anxiety is high, that's because public trust and confidence in the NRC is low.

Public trust and confidence in the NRC should be a prerequisite for allowing a troubled reactor continuing to operate.

That trust and confidence is missing; and the NRC must take steps to restore it. The NRC should consistently establish, and enforce, safety regulations. NRC senior managers must stop looking for absolute proof that operating reactors are unsafe and instead look for absolute proof that operating reactors comply with federal safety regulations.

When NRC senior managers see safety problems, they must disclose that finding to the public. Hiding such information, as the NRC did with the flooding vulnerabilities at Oconee, provides the public with a distorted view. The NRC's antics provide the public with zero

reason to trust anything the NRC utters. When you cherry-pick what you say and report only the positive, you stop being a credible authority.

If the NRC allows Pilgrim to continue operating and the reactor has an accident, will NRC commissioners and staff be able to honestly look victims and survivors in the eye and say the NRC did everything they could to protect them?

ACCIDENT RESPONSE

- **EMERGENCY PLANNING**
- **POST ACCIDENT CLEANUP**

EMERGENCY PLANNING

After shutdown, we believe (contrary to NRC) that offsite emergency planning must remain in place until all the spent fuel is unloaded from the pool and placed in passive dry casks.

The recent events in Japan remind us that while the likelihood of a nuclear power plant accident is low⁷², its potential consequences are grave. An accident like Fukushima could happen here. An equipment malfunction, fire, human error, natural disaster or terrorist attack could—separately or in combination—lead to a nuclear crisis. Emergency procedures are important and as shown below need to be significantly improved.

Today, Pilgrim’s Radiological Emergency Response Plan does not provide reasonable assurance that adequate protective actions are in place to protect the health and safety of the public. Protective actions are taken to avoid or reduce radiation dose and are sometimes referred to as protective measures.

Examples: (i) Duxbury’s Fire Chief and Emergency Management Director after the January 27, 2015 winter storm Juno stated clearly that “the days following the storm that Duxbury could not implement its evacuation component of the plan due to the snow amounts.”

*(ii) Event Number: 53242 POTENTIAL LOSS OF OFFSITE RESPONSE CAPABILITIES
“At 2315 EST on March 2, 2018, Pilgrim Nuclear Power Station (PNPS) determined, based on information received from the Commonwealth of Massachusetts, that there may be a potential loss of offsite response capabilities due to ongoing severe natural hazard conditions (i.e., major winter storm) along the coast of Massachusetts. According to information received by PNPS, towns within the 10 Mile EP Radius could be hampered in implementing some protective actions specified in the emergency plan.” Pilgrim remained operating.*

Agency Roles and Responsibilities in Emergency Planning:⁷³

NRC: A key component of the NRC’s mission is to ensure that adequate protective actions are in place to protect the health and safety of the public.

FEMA’s (DHS) role and responsibility are to evaluate nuclear plant offsite emergency plans to ensure that they are adequate to protect public health and safety for NRC’s review to ensure adequate protective actions are in place.

Fukushima raised the baseline from 1 event per 31,000 RY to 1 event per 2,900 RY: The NRC’s current baseline estimates that there may be *one Core Damage Event per 31,000 RY* (years of reactor operation). Fukushima raised the number of *actual* core damage events at Generation II commercial reactors in the last 34 years to five⁷² - TMI, Chernobyl and Units 1 through 3 at Fukushima. Based on this actual experience, the likelihood of a significant accident core melt in any given year is about 1 in 7.

The chance of a GE Mark I Boiling Water Reactor like Pilgrim self-destructing with massive offsite contamination is about 1 in 8. This statement is based on the real-world experience of four such reactors having self-destructed in Japan (out of 33 ever built). Each failed due to a loss of offsite power (which doesn’t require a tsunami), a situation they were designed to accommodate. Three suffered complete meltdowns, one (with no fuel in the reactor) had a series of severe explosions; it may be the greatest threat of all.

⁷³ See <http://www.nrc.gov/about-nrc/emerg-preparedness/protect-public.html>

State and local governments implement appropriate protective actions for the public during a nuclear power plant radiological emergency.

The NRC itself does not review a plant's emergency plan to ensure that there is reasonable assurance that the plan, including the availability of evacuation routes, is adequate to protect public health and safety. Rather, it relies on the Federal Emergency Management Agency (FEMA or DHS) and the Massachusetts Emergency Management Agency (MEMA) to do so.

The Commonwealth has the ability to require more conservative measures. To date, it has not done so.

The Town of Duxbury's Radiological Emergency Plans and Procedures are available on line. See the Town of Duxbury Radiological Emergency Plan and Standard Operating Guidelines (SOGs) at: http://www.town.duxbury.ma.us/Public_Documents/DuxburyMA_EMA/index The plans and procedures for the other EPZ communities are essentially the same.

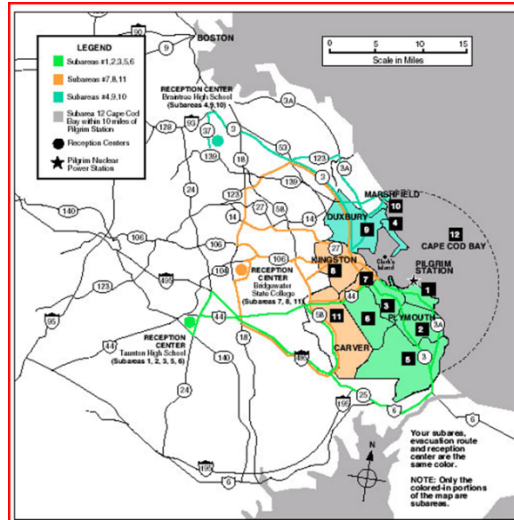
What's Wrong with Pilgrim's Emergency Plans?



Size of Emergency Planning Zone (EPZ): There are two emergency planning zones (EPZs) around each nuclear power plant.

The Plume Exposure Pathway EPZ has a radius of about 10 miles from the reactor site and is divided into sub-areas. Predetermined protective action plans are in place for this EPZ theoretically designed to avoid or reduce dose from potential exposure of radioactive materials. These actions include sheltering, evacuation, and the use of potassium iodide.

The ingestion Exposure Pathway EPZ has a radius of about 50 miles from the reactor site. Predetermined protective action plans are in place for this EPZ and are designed to avoid or reduce dose from potential ingestion of radioactive materials. These actions include a ban of contaminated food and water.



There is no escape from the Cape. MEMA's plan for the Cape in the event of a severe accident at Plymouth's Pilgrim reactor is to close the Sagamore Bridge and⁷⁴ to prohibit outgoing traffic over the Bourne Bridge until the the 10-mile emergency planning zone is cleared. The *Cape Cod Telephone Survey Results*, July 25, 2013 (funded by Entergy in 2013) showed that 70% of respondents said they would evacuate if told there was an incident at Pilgrim and 50% of respondents out to 25 miles said they would evacuate even if told they were not in the evacuation zone. It shows that the NRC's Evacuation Time Estimate's conclusion that even in the worst case scenario only 20% of the shadow population will choose to evacuate is absurd.⁷⁵



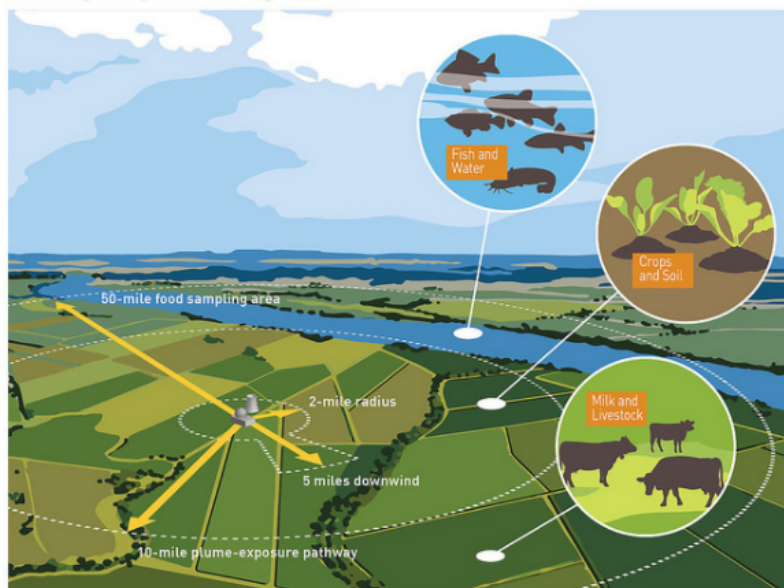
⁷⁴ <http://capedownwinders.org/emergency/>; <http://capedownwinders.org/memas-plan-for-the-cape-in-the-event-of-a-severe-accident-at-plymouths-pilgrim-reactor-is-to-close-the-sagamore-bridge/>

⁷⁵ Pilgrim Watch's 2.206 Petition To Modify, Suspend, Or Take Any Other Action To The Operating License Of Pilgrim Station Until The Nrc Can Assure Emergency Preparedness Plans Are In Place To Provide Reasonable Assurance Public Health & Safety Are Protected In The Event Of A Radiological Emergenc, NRC Adams Library, Accession No., MI13267a234

Lessons learned from Fukushima: NRC advised Americans in Japan within 50 miles of Fukushima to evacuate. Tokyo, located about 140 miles south of Fukushima, announced that its tap water is contaminated with radioactive iodine and that “hot spots” well beyond 50 miles in Japan had contaminated food and water. Pilgrim’s ingestion zone is only 50 miles.

Japan is expanding its EPZ; the NRC has gone in the opposite direction. NRC and FEMA assume that in a nuclear emergency only those within a 2- mile radius of the plant and those within a narrow pie shaped wedge, or keyhole downwind, from 2 miles to perhaps 5 miles or at most 10 miles will be required to evacuate (issued December 23, 2011).

Emergency Planning Zones



Note: A 2-mile ring around the plant is identified for evacuation, along with a 5-mile zone downwind of the projected release path.

As of July 2017

U.S. NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

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We suspect that the reasons for NRC’s policy are two-fold.

First, reactors were originally built in sparsely populated areas; but the population in those areas has now greatly expanded making it impossible to evacuate the population in a timely manner. The AP reported that populations within 10 miles of reactors have ballooned to as much as 4 1/2 times since 1980 and about 40% of the US population live within 50 miles of a reactor, based on the 2010 Census data. Therefore, what the NRC really is saying that if the public cannot evacuate in a timely manner, plans then will say that they do not have to evacuate.

Second, the policy is in part a public relations ploy – downplaying what might happen in order to counter public post-TMI-Chernobyl-Fukushima “jitters” and further turning public opinion against the industry.

⁷⁶ NRC Information Digest, 2017 <https://www.flickr.com/photos/nrcgov/sets/72157685497524780/>

NRC's and FEMA's public relations department worked overtime. It approved Pilgrim's evacuation time estimate that concluded the entire 10-mile emergency planning zone could be evacuated within six hours.⁷⁷ The absurd conclusion was based on inaccurate assumptions.⁷⁸

Meteorological Plume Model: Planners incorrectly assume that winds blow in a straight-line and rely on an outdated straight-line Gaussian plume model that is not spatial or temporal. For a Gaussian model to be at all meaningful, it is essential that (1) there be a non-zero wind speed, (2) wind direction is constant over time in downwind areas, (3) the release rate be constant over time for the duration of the release, and (4) the atmospheric stability be constant over time in downwind area. But winds are variable especially near large bodies of water, river valleys and varied terrain.⁷⁹ Therefore basing protective action calls on a "key-hole" (pictured in above diagram) makes no sense and will result in planners issuing the wrong protective action- evacuation into a plume or no protective action call for those actually in a plume.

Notification: (1) *Public:* Sirens are the primary method of public notification; however, they are essentially outdoor warning systems and often cannot be heard above normal ambient noise by people who live and work inside. This is particularly true in cooler climates where houses are insulated and outfitted with storm windows; in hot climates where air conditioners are standard; and in suburban and exurban areas where houses are set back on sizeable lots with generous landscaping that buffers sound. The following systems should be added: rapid dialing systems, electronic reader boards, low frequency dedicated radio capability and EAS be required. (2) *Emergency Workers:* Currently their radios are not interoperable. They need to be upgraded to today's technology *so that* they can talk to one another within the EPZ and to other towns outside the EPZ for mutual aid.

Potassium Iodide (KI): In a nuclear reactor accident, radioactive iodine is released; it can cause thyroid cancer/disease, and mental retardation in children of exposed pregnant women. Children and infants, including the unborn, are most vulnerable. KI blocks the thyroid with a harmless form of iodine. KI must be taken before or shortly after exposure - within six hours. It does not protect against other harmful radioactive releases or other potential health effects, just as polio vaccines do not protect against cancer; but that is no reason not to get and take it. One dose of KI protects for 24 hours. KI is FDA approved and stockpiled around the world. Adverse reactions are possible for those who are allergic to iodine – shellfish or salt.

KI is provided by NRC to states that request it for communities within the 10 mile EPZ. However in 2002, Congress passed Section 127 of the Bioterrorism Preparedness and Response Act that extended KI to 20 miles. It has not been implemented for political reasons. Massachusetts passed a bill that offers KI to communities on Cape Cod and Cape Ann. *KI should be provided to those within 20 miles, as shown in*

⁷⁷ KLD Pilgrim Evacuation Estimate December 12, 2012 Final Report KLD-TR-510 available at NRC Electronic Library, Accession Number ML13023A031

⁷⁸ See Pilgrim Watch 2.206 Petition at NRC Electronic Library, Accession Number ML13267A234 <https://www.nrc.gov/docs/ML1326/ML13267A234.pdf>

⁷⁹What's in the Black Box known as Emergency Dose Assessment, Stephen LaVie, Sr. Emergency Preparedness Specialist, Nuclear Security & Incident Response Division of Preparedness, and 2009 Report to National Radiological Emergency Planning Conference, Slide 2, Dispersion, NRC Electronic Library, Adams Accession Number ML091050257

Japan, and stockpiled in schools, day care centers, camps, shelters, group homes and other public facilities. U.S. Nuclear Regulatory Commission, NUREG/CR 1433 showed that for children, the following dangers may occur from the inhalation of nuclear materials after a massive core-melt atmospheric accident (like Chernobyl).

Approximate Dangers of a Core-Melt Atmospheric Accident for Children

Distance in Miles	Mean Thyroid Dose (rem) for Exposed Children Outdoors*	Probability of Thyroid Damage to Exposed Children Located Outdoors if not Protected by Stable Iodine (like KI)
1	26,000	100%
5	11,600	100%
10	6,400	100%
25	2,200	80%
50	760	26%
100	200	7%
150	72	2%
200	32	1%

Chernobyl: NRC's NUREG-1623 points out that radioactive iodide can travel hundreds of miles on the winds. An increase in cancer caused by Chernobyl was detected in Belarus, Russia, and Ukraine. Notably, this increase, seen in areas more than 150 miles from the site, continues to this day and primarily affects children who were 0-14 years old at the time of the accident. The vast majority of thyroid cancers were diagnosed among those living more than 31 miles from the site. The 2001 figures were 11,000 thyroid cancers at 31 miles. The increase in disease was attributed to **both inhalation and ingestion** of contaminated foods.

World Health Organization: (1999) World Health Organization (WHO) *Guidelines for Iodine Prophylaxis following Nuclear Accidents* states in its abstract regarding thyroid cancer caused by the Chernobyl disaster:

This increase in incidence has been documented up to 500 km from the accident site. (And therefore) that stockpiling (KI) is warranted, when feasible, over much wider areas than normally encompassed by emergency planning zones, and that the opportunity for voluntary purchase be part of national plans."

For more information see:<http://www.mass.gov/eohhs/consumer/community-health/environmental-health/exposure-topics/radiation/ki/>

Shadow Evacuation: Currently the Federal government incorrectly assumes that only 20% of those within 10-15 miles from the reactor will evacuate; and that only 20% within the 10-mile EPZ who are told not to evacuate will nonetheless do so. This assumption was proved false by a 2013 Telephone Survey on Cape Cod⁸⁰ that showed that if potentially affected respondents were asked "would you evacuate" "if they were an incident at the Pilgrim Nuclear Power Station," 70% (not the 20% assumed by the NRC or the 19% of the ETE) would do so. The survey also found that if the respondents were told that the Cape

⁸⁰ KLD MEMO to John Giarrusso (MEMA) from Chris Chaffee (KLD) Regarding the Cape Cod Telephone Survey Results, July 25, 2013

is not in the Emergency Evacuation Zone, 50% said that they would evacuate if there were an incident at Pilgrim.

Unless current plans come to grips and plan for and control the likelihood of spontaneous evacuation of the public beyond the federal guidance, those most at risk will be trapped in gridlock.

Cape Cod Traffic July 29, 2013 – Cars provide no protection

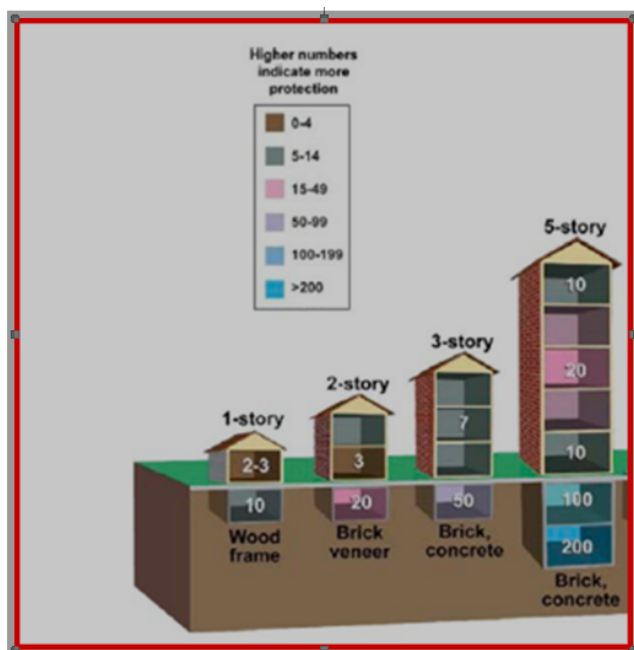


Transportation For Transportation Dependent (especially school children and elderly): Mobilize busses from outside the impacted area at the Alert, beginning stage of accident; assure that busses housed in a likely-to-be-impacted community are for *the exclusive use* of that community in a radiological disaster and, not as now, allowed to be directed to another community.

Reception Centers: (1) Location- The key to any site used to for monitor and decontaminate citizens is that it is sufficiently distant from the reactor and placed, according to meteorological analysis, in areas likely to be upwind. (2) Capacity- Plans assume that only one in five (20%) will go to the Reception Center, and Reception Centers are only equipped with personnel and materials to handle 20% – despite the fact that NUREG 0654 (J-12) says that Reception Centers should be capable of monitoring 100% of the population within 12 hours. This policy leaves 80% without an opportunity to be monitored and decontaminated, risking their health and risking spreading contamination to heretofore “clean” areas via contaminated evacuees cars and persons. The 20% policy is based on the number of people who went to a reception center during a Florida hurricane; but as the Cape Survey showed, public response in very different for nuclear disaster than for hurricanes. There is forewarning to hurricanes, not nuclear disasters. People fear nuclear disasters far more than hurricanes.

Shelters: Equip all shelters in the expanded EPZ with KI and face masks; and educate the public where and how to shelter in the event of a disaster – shelter in an area as distant from the roof as possible and away from all windows, gamma radiation can go through window glass.

Where to Shelter



A dose factor of 10 for example means that a person in that area would receive 1/10 of the dose of a person outside.

[Source: EPA Protective Action Guidance for Radiological Incidents, March 13, 2013]

Worker Safety: Provide all emergency workers with protective gear, dosimetry and KI. Locate the Radiological Emergency Workers Monitoring & Decontamination centers (REWMDs) outside the peak fatal zones – preferably 20-25 miles away. At Pilgrim NPS, the REWMDs is within the “peak injury zone” and close to the “peak fatal zone.” It is located in Carver, directly across the street from the 10-mile demarcation line. It should be moved. There should be more than one center for each EPZ – so that there is an alternative site if the wind is blowing towards one of the centers or access routes clogged with evacuees.

Exercises: Add reality to the emergency exercises, for example, by having some drills unannounced, some held during off-business hours, and some involving actual drills at schools with the teachers and pupils as is done for fire drills.

EPA recently Draft Protective Action Guidelines (PAG)⁸¹

The Draft PAG provides radiological protection criteria (PAGs and protective actions) for all incidents that would require consideration of protective actions, with the exception of nuclear war. It says that the “PAGs are not legally binding regulations or standards and do not supersede any environmental laws.” However state and local responders treat the Manual as the Gospel. The Draft PAG Manual should make clear, but does not, what specific regulations or standards require. A simple table should be included in the final document laying out side by side the PAGs and all other pertinent standards, as opposed to only footnotes providing links to those standards, as in the draft. The PAG Manual divides into three sections: Early Phase Protective Action Guides; Intermediate Phase Protective Action Guides; and Late Phase Protective Action Guides. EPA’s draft largely provides a broad-brushed description of radiological

⁸¹ <http://www.epa.gov/radiation/docs/er/pag-manual-interim-public-comment-4-2-2013.pdf>

emergency plans at each stage; and not enough attention is given to what the plans should be in order to reflect lessons learned from Fukushima and to protect public health and the environment.

The EPA Draft Manual guidance is also inadequate. It does not advocate, as it should, advanced meteorological plume modeling, the importance of real-time offsite radiological air monitors, or enhanced environmental sampling. Its dose guidance is not based on the National Academies of Sciences, BEIR VII (see following health section); guidance for Potassium Iodide is incorrect and, unlike guidance from the FDA, goes so far as to discourage its use. The Manual's discussion of cleanup avoids the key questions - what federal agency is in charge, who pays, and how clean is clean enough. It also ignores that cleanup after a large accident simply is not possible. Comments submitted are available on: <http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OAR-2007-0268>

POST-ACCIDENT CLEANUP

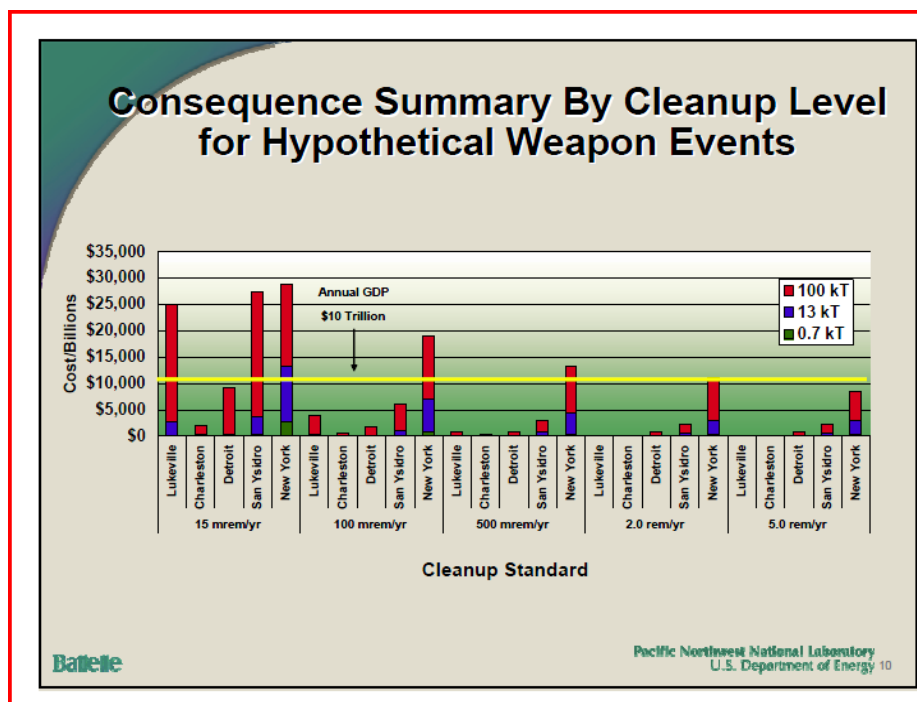
No Agreed Upon Cleanup Standard - No Federal Agency In Charge - No Money – States and Towns Responsible for Waste Disposal – Homeowners Not Insured for Nuclear Accidents

Clean-up Standard

The cleanup standard is the driving factor both for determining offsite cost, and for the public health and safety. Yet the responsible federal agencies have yet to agree what the cleanup standard should be. The US Department of Homeland Security has commissioned studies for the economic consequences of a Rad/Nuc attack. Much more deposition would occur in a reactor accident, magnifying consequences and costs. However there are important lessons to be learned from these studies.

Barbara Reichmuth's study, *Economic Consequences of a Rad/Nuc attack: Cleanup Standards Significantly Affect Cost*, 2005,⁸² Table 1 Summary Unit Costs for D & D (Decontamination and Decommissioning) Building Replacement and Evacuation Costs provides estimates for different types of areas from farm or range land to high density urban areas. Reichmuth's study also points out that the economic consequences of a Rad/Nuc event are highly dependent on cleanup standards: "***Cleanup costs generally increase dramatically for standards more stringent than 500 mrem/yr.***" (Emphasis added)

⁸² Economic Consequences of a Rad/Nuc attack: Cleanup Standards Significantly Affect Cost Barbara Reichmuth, Steve Short, Tom Wood, Fred Rutz, Debbie Swartz, Pacific Northwest National laboratory, 2005



What agency (NRC, EPA, DHS) is in charge of cleanup?

What agency is in charge after an accident has not been determined. Absent a lead agency, cleanup will be delayed becoming more difficult and costly impacting the time the population is displaced and whether recovery and return is possible.

Who pays? Your Home Insurance Doesn't Cover Nuclear Accidents

Price-Anderson,⁸³ is the nuclear industry's indemnity act, is underfunded and covers only the cost of property damage; *it does not cover cleanup*. Real-world experience in Fukushima has made it clear that actual clean-up costs will be far more than Price-Anderson provides. A 2014 study at Osaka State University estimated that the cost of the tragedy at Fukushima will be \$105 billion.⁸⁴ This is no surprise because the Price-Anderson amount was based on the outdated and flawed computer codes used to

⁸³ Price Anderson is the nuclear industries indemnity or insurance, established by Congress in 1957. The purpose is to indemnify the industry against liability claims in the event of an accident and ensure monies for the public. Act establishes a no fault insurance type system in which the first approximately \$12.6 billion (as of 2011) is industry-funded as described in the Act. Any claims above the \$12.6 billion would be covered by a Congressional mandate to retroactively increase nuclear utility liability or would be covered by the federal government.

⁸⁴ <https://www.rt.com/news/183052-japan-fukushima-costs-study>. The cleanup will take decades, and this recent estimate is more than 7 times the \$14 billion that the Japanese government budgeted through March 2014. In 2013, the Japanese Environment Ministry said the cleanup was expected to generate at least 100 million cubic meters or 130 million cubic yards of soil, enough to fill 80 domed baseball stadiums (Japan decontaminates towns near tsunami-hit nuclear plant, unsure costly effort will succeed, Associated Press, Mari Yamaguchi, March 5, 2012)

assess risk - Melcor Consequence Computer Code and SOARCA.⁸⁵ See discussion in the section, Assessment of Risk, Probabilistic Risk Assessment.

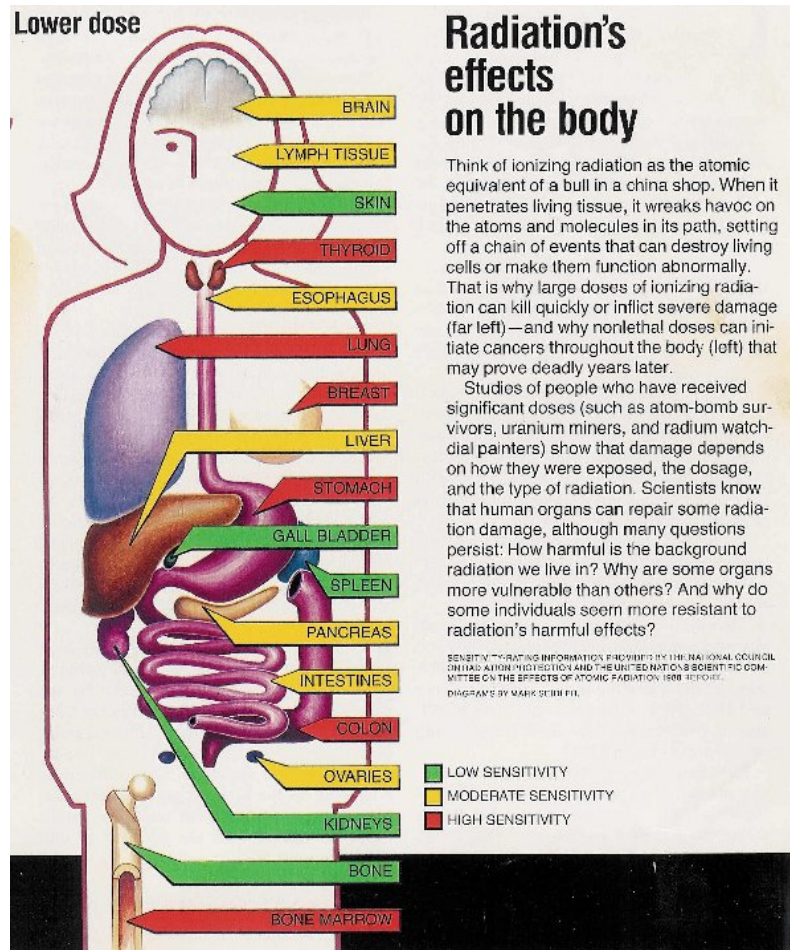
RISK FROM DAILY OPERATIONS

Radiation Health Impacts
Monitoring
Marine Impacts

⁸⁵ See Comments by Pilgrim Watch Regarding SECY-12-0110, Consideration of Economic Consequences within the NRC's regulatory framework: <http://www.nrc.gov/reading-rm/doc-collections/commission/slides/2012/20120911/>

RADIATION & HEALTH

Radiation's Effects On The Body



Radioactive Releases Occur Routinely. It doesn't take an accident at Pilgrim to release radioactivity into our air, water, and soil. As a matter of routine operation, radiation is released from Pilgrim in the form of liquid, gaseous, and solid radioactive wastes. Solid radioactive wastes include anything from laundry (considered low-level waste) to spent fuel rods (considered high-level waste.)

The released radioactivity over 100 different isotopes that are only produced in reactors and atomic bombs, including Strontium-89, Strontium-90, Cesium-137, and Iodine-131. Humans ingest them either by inhalation or ingestion, through food. Each radionuclide seeks different parts of the human body; iodine seeks out the thyroid gland, strontium clumps to the bone and teeth (like calcium), and cesium is distributed throughout the soft tissues. All are carcinogenic. Each decay at varying rates; for example, iodine-131 has a half-life of eight days, and remains in the body only a few weeks. Strontium-90 has a half-life of 28.7 years, and thus remains in bone and teeth for many years. These radionuclides are different from "background" radiation found in nature in cosmic rays and the earth's surface.

Background radiation, while still harmful, does not specifically attack the thyroid gland, bones, or other organs.

Permissible Releases Do Not Mean Safety. Government regulations allow “permissible” levels of contamination. However, there is no safe threshold to exposure to radiation, so “permissible” does not mean “safe.” NRC’s allowable radioactive release dose from a nuclear reactor to members of the public is 100 millirem per year to the total body. The National Academy of Sciences Biological Effects of Radiation (BEIR VII) Report published June 2005 reported that the **lifetime fatal cancer risk for 100 mrem/yr is 1 in 175 and the cancer incidence risk is 1 in 100.** Pilgrim claims to release a tiny fraction of the permissible dose; if this is so, why does industry fight changing the standard to a far lower number to better protect public health?

What Independent Scientists Say

National Academy of Sciences, BEIR VII Report, June 2005⁸⁶

The National Academy of Sciences (NAS) latest report on radiation risk, called the BEIR VII report (“BEIR” stands for the Biological Effects of Ionizing Radiation) was issued June 2005. Its conclusion was simple: No amount of radiation is safe, and women and children are the most at risk.

Women and Children Most at Risk: The National Academy reported that overall cancer mortality risks for females are 37.5 percent higher than for men, and the risks for all solid tumors (lung, breast, and prostate) are almost 50 percent higher. The differential risk for children is even greater. The same radiation in the first year of life for children produces three to four times the cancer risk as exposure between the ages of 20 and 50. Female infants have almost double the risk as male infants.



Image: Beyond Nuclear 06.16.15

Impact Offspring from Parents Exposure: While the report states there is no direct evidence of harm to human offspring from exposure of parents to radiation, the committee noted that such harm has been

⁸⁶ The National Academy’s Report is available on the Web at <http://books.nap.edu/>

found in animal experiments and that there is “no reason to believe that humans would be immune to this sort of harm.” This should be of concern to nuclear worker’s families.

Heart Disease and Stroke: Here again, the National Academy stated that no amount of radiation exposure is safe; and noted that relatively high levels of radiation exposure increase risk not only of cancer but also of heart disease and stroke.

What does this mean for us? The 1 in 100 risks of cancer posed by the NRC’s 100 millirem/year standard far exceeds the risk that other agencies allow for other carcinogens.⁸⁷ These risks are much higher than permitted for other carcinogens - the allowable release for one chemical from a factory is a lifetime cancer incidence risk of (1) in a million. Apparently it is permissible for Pilgrim to cause cancer in TEN THOUSAND times as many people that would be permitted for an ordinary chemical factory.

EPA Draft Protective Action Guidelines (PAGS)⁸⁸

See the comments of Dr. Daniel Hersch and comments by Dr. Arjun Mahkijani, Institute Energy & Environment Research.⁸⁹

Highlights: What is wrong with the PAGS and how EPA is abdicating its responsibility to protect public health:

1. EPA eliminates the existing requirements from the 1992 PAGs triggering evacuation when thyroid or skin doses exceed specified limits.
2. EPA eliminates the existing relocation limit of 5 rems cumulative dose over 50 years, saying it might conflict with their long-term cleanup approach, which in new associated guidance from NCRP would allow cumulative 50-year doses of 100 rems, twenty-fold higher. *Even thirty years’ exposure at the 2 rem/year (see 6, below) would, by EPA’s own official risk estimates, result in an excess cancer in every eighth person exposed; orders of magnitude higher risk than EPA has ever considered acceptable.*
3. EPA incorrectly argues that relaxed long-term standard is somehow justified because the public’s exposure will not be for 70 years. But this is a disingenuous argument. The core of the long-term cleanup part of the PAGs is setting a very high permissible annual dose that one would be allowed to get for a whole lifetime (indeed, the standard 70-year lifetime assumption) without the government having to cleanup at all. The one-year exposure is for the intermediate phase; the long-term phase is forever, and that is what is so troubling about relaxing long-term cleanup standards.
4. EPA says that the Safe Drinking Water Act Maximum Contaminant Limits (MCLs) may not be appropriate. In footnotes, it proposes five far laxer alternatives. Those proposed weaker limits would allow concentrations of radionuclides in drinking water orders of magnitude higher than considered safe by EPA under the Safe Drinking Water Act. I have attached two tables Dr. Hirsch put together comparing these levels for four key radionuclides. Their proposals are frequently as bad as the Bush water PAG proposal and in some cases worse. Generally, *EPA is proposing*

⁸⁷ For a worker, risk is even greater. The National Academy estimate is that 1 in about 5 workers would get cancer if exposed to the legally allowable radiation occupational doses over their 50 years in the workforce.

⁸⁸<http://www.epa.gov/radiation/docs/er/pag-manual-interim-public-comment-4-2-2013.pdf>

⁸⁹ Dr. Arjun Mahkijani at <http://ieer.org/resource/nuclear-power/comments-epa-radiation-protection/>

allowing hundreds to tens of thousands of times higher concentrations of radioactivity in drinking water than EPA has historically allowed as safe under the Safe Drinking Water Act.

Obama Drinking Water PAG proposals vs. Existing EPA Safe Drinking Water Levels and Bush Administration PAG Proposal
units = Bq/L

Radionuclide	EPA Safe Drinking Water Act Maximum Contaminant Limit (MCL)	Bush Proposed Drinking Water PAG	Obama Proposed Drinking Water Page Alternative I (EPA 2013 fn 26)	Obama Proposed Drinking Water PAG Alternative II (EPA 2013 PAG fn 25)	Obama Proposed Drinking Water PAG Alternative III (EPA 2013 PAG fn 27)	Obama Proposed Drinking Water PAG Alternative IV (EPA 2013 PAG fn 24a)	Obama Proposed Drinking Water PAG Alternative V (EPA 2013 PAG fn 24b)
Iodine-131	0.111	314	314	3000	170	10	300
Strontium-90	0.296	246	246	200	160	10	
Cesium-137	7.4	503	503	2000	1200	10	
Plutonium-239	0.555	27	27	50	2	1	

Factors by Which Obama Drinking Water PAG Proposals Would Exceed Existing EPA Safe Drinking Water Levels

Radionuclide	Bush Proposed Drinking Water PAG	Obama Proposed Drinking Water Page Alternative I (EPA 2013 fn 26)	Obama Proposed Drinking Water PAG Alternative II (EPA 2013 PAG fn 25)	Obama Proposed Drinking Water PAG Alternative III (EPA 2013 PAG fn 27)	Obama Proposed Drinking Water PAG Alternative IV (EPA 2013 PAG fn 24a)	Obama Proposed Drinking Water PAG Alternative V (EPA 2013 PAG fn 24b)
Iodine-131	2829	2829	27027	1532	90	2703
Strontium-90	828	828	676	541	34	
Cesium-137	68	68	270	162	1.35	
Plutonium-239	49	49	90	3.6	1.8	

Note: Second vertical column, "Obama proposed Drinking Water Page" should read PAGs not Page

- EPA incorporates 1998 guidance allowing extremely high contamination of food, despite internal EPA criticism of doing so which said it would produce a cancer in every fiftieth person so exposed.
- EPA incorporates the DHS PAGs for dealing with long-term cleanup from a nuclear weapons explosion and applies it to any kind of release. The DHS PAG is based on "optimization" and contemplated permitting long-term doses as high as several rems per year. *The new PAG is tied to the NCRP new guidance which would allow doses up to 2 rems per year over a lifetime (the equivalent of about 1000 extra chest X-rays every year, or 3 X-rays every day of your life from birth to death). EPA's estimate of a 70-year lifetime exposure at that level would be one in every six people exposed would get cancer* (the risk coefficient they use is different for exposure over a lifetime than for earlier years because of the elevated risk at younger ages
- The associated_NCRP guidance on implementing the PAGs for long term cleanup recommends radionuclide concentration levels so high that they would allow concentrations for strontium-90, for example, hundreds of thousands of times higher than the EPA's official Preliminary Remediation Goals for the same exposure scenarios. They would produce cancer risks using EPA's risk figures in the several cancers per ten people exposed, orders of magnitude outside the long-held acceptable risk range.
- The PAGs and the documents associated with them are saying nuclear power accidents could be so widespread and produce such immense radiation levels that the government would simply

abandon most cleanup obligations and force people to live with exposures so high that extremely large fraction of the exposed population would get cancer from the exposure.

9. Troubling in a different fashion, EPA buries the “bad stuff” in footnote references to a whole series of other documents, so it is hard for a lay reader to see the troubling things EPA has done. EPA thereby has made the PAG manual itself essentially useless in a real accident. It was supposed to be a stand-alone, clear document that a first responder could take off the shelf, look up a table in it, see if a radiation level exceeded a PAG and if so, undertake the protective action described therein. But all of that is now removed from the PAG document. Instead, there are footnotes to URLs for numerous referenced documents, most of which are contradictory, so that the PAG does not achieve its intention to be useful in providing some guidance.

Furthermore, EPA is statutorily mandated to produce PAGs and other radiation guidance for the rest of the federal family and historically has viewed DOE and NRC as not sufficiently protective in radiation matters. The PAG now abdicates EPA's responsibility to come up with guidance and instead references almost exclusively documents from DOE that EPA has historically opposed. It now directs the use of DOE's Operational Guidance document which uses cleanup concentrations hundreds of thousands of times higher than EPA's official concentrations. Rather than use its own conversions from concentration to risk, EPA now defaults to DOE's models, documents, and values with which it has long disagreed as technically not defensible and not sufficiently protective. But at the end of the day, no emergency responder will have a Protective Action Guide that is useable.

If it were used, however, it would allow doses to the public so far outside the range ever considered acceptable as to be deeply disturbing.

National Academy of Sciences Proposed Analysis of Cancer Risks

A 1990 NRC cancer study of cancer around nuclear reactors compared cancer data in a county hosting a reactor to cancer data in a neighboring county. The 1990 study found no increase in cancer in the host county. This came as no surprise because the methodology was flawed. It ignored the facts that a county is too large a geographic area, and it ignored where the reactor was located in the county. Was the reactor located in the middle of the county or closer to the neighboring county's border? Were prevailing winds blowing toward the neighboring county?

In 2010, NRC decided to update the study.⁹⁰ First, NRC gave a no-bid contract to the Oak Ridge Institute for Science and Education (ORISE) - a U.S. Department of Energy institute focused on researching health risks from occupational hazards.

Members of Congress and the public saw a conflict of interest. The study was then turned over to the National Academies of Sciences. NAS planned to analyze cancer around nuclear reactors in two consecutive phases.

A Phase 1 scoping study was to identify scientifically sound approaches for carrying out an epidemiological study of cancer risks. This scoping study began September 1, 2010, and was scheduled to last for 15 months. The result of this Phase 1 study was to be used to inform the design of the cancer risk assessment, which would be carried out in a future Phase 2 study.

The Phase 2 study of cancer risks in populations near seven U.S. Nuclear Regulatory Commission (U.S.NRC)-licensed nuclear facilities was supposed to use two epidemiologic study designs: (i) an ecologic study of multiple cancer types of populations of all ages and (ii) a record-linkage-based case-control study of cancers in children. The pilot study was to have two steps: Pilot Planning and Pilot Execution.

⁹⁰ <http://www.beyondnuclear.org/radiation-health/?currentPage=16>

The National Research Council said the Pilot Planning step was estimated to take one year to complete. The seven nuclear facilities that were to be part of the pilot study were: Dresden Nuclear Power Station, Morris, Illinois; Millstone Power Station, Waterford, Connecticut; Oyster Creek Nuclear Generating Station, Forked River, New Jersey; Haddam Neck, Haddam Neck, Connecticut; Big Rock Point Nuclear Power Plant, Charlevoix, Michigan; San Onofre Nuclear Generating Station, San Clemente, California; and Nuclear Fuel Services, Erwin, Tennessee.

NRC Cancelled the NAS Study of Cancer Risks around U.S. Nuclear Reactors⁹¹

NRC Press Release (September 8, 2015) said that:

The NRC determined that continuing the work was impractical, given the significant amount of time and resources needed and the agency's current budget constraints. The NRC continues to find U.S. nuclear power plants comply with strict requirements that limit radiation releases from routine operations. The NRC and state agencies regularly analyze environmental samples from near the plants. These analyses show the releases, when they occur, are too small to cause observable increases in cancer risk near the facilities. 'We're balancing the desire to provide updated answers on cancer risk with our responsibility to use Congressionally provided funds as wisely as possible,' said Brian Sheron, director of the NRC's Office of Nuclear Regulatory Research. 'The NAS estimates it would be at least the end of the decade before they would possibly have answers for us, and the costs of completing the study were prohibitively high.'

NAS Press Release (September 10, 2015): NAS corrected press and NRC reports and said that:

The NRC cited the long duration and high cost of the NAS pilot study, and the long duration of a subsequent nationwide study, as reasons to end the study. Several media outlets have reported incorrectly that NAS estimated the pilot study would take 8 to 10 years to complete at a cost of \$8 million. In fact, the NAS estimated that it would take 39 months at a cost of \$8 million to complete the pilot study of 7 nuclear facilities, which was intended to inform the feasibility, schedule, and cost of a nationwide study. NAS did not provide time or cost estimates for a nationwide study. The NRC made its own estimate that it may take 8 to 10 years to complete both the pilot and subsequent nationwide studies and offered no additional cost estimate.

David Lochbaum, UCS, Comment - zeroed in on the important point:

[NRC] contends that it would take \$8 million and many more years to complete the NAS study, despite NAS having already spent some years at it. Let's stipulate this is all true and accurate.

⁹¹ <https://safeenergy.org/2015/09/14/nrc-drops-cancer-study/on-the-study>

So, the NRC is many years away from knowing whether routine releases have adverse consequences. How can they extend the operating lifetimes of existing reactors or license new reactors given uncertainty about this vital public health question?

Clearly, the scope of work is not merely updating the early 1990s study to account for population differences, etc. That it would take so much time and effort to complete the ongoing study is strong prima facie evidence that the existing study is fundamentally deficient.

Again, if the evaluation of record is so deficient and outdated that it would take another \$8 million and many more years to fix it, how can the NRC use its results to make decisions about public health? Even at NRC's low-ball value of \$3 per human (i.e., non-NRC) life, the study would only have to save three lives to be cost-justified.

Pilgrim- Radiation Health Impacts - Southeast Mass.

Increases in radiation-linked disease in the communities around Pilgrim were in part attributed to operating with defective fuel; operating without the off-gas treatment system in the first years; poor management and practices culminating in the releases in June 1982 that coincided with weather conditions that held the releases over surrounding communities and parts of Cape Cod.

Pilgrim Radiological Environmental Monitoring Program Report 1982

MEDIA	PAGE	RADIONUCLIDE	TIMES EXPECTED	HALF-LIFE
SHELLFISH	3-43	Cs-137		30 yrs
		Co-60		
		I-131	High, discharge canal	8 days
FISH	3-60	Cs-137		30-yrs
		I-131		8 days
SEDIMENT	3-62	I-131	Highest mean in Marshfield	8 days
		Co-60		
MILK	3-69	Cs-137	1,000,000	30 yrs
		Sr-89/90	1,000,000	29 yrs
	D-3	I-131	2X Regulatory Guide 4.8	
CRANBERRIES	3-76	Cs-137		30 yrs
		I-131		8 days
VEGETATION	3-80	Cs-137	1,000,000	30 yrs

NOTE Effluent & Waste Disposal Semi-Annual report (1982), page 8A, said that a total of more than 819 curies of spent resin, filter sludges, evaporator bottoms were transported out of Pilgrim. It was the year that Pilgrim blew their filters, on June 11, 1982

The cancers found in the communities around the power station were studied by Dr. Sidney Cobb and Dr. Richard Clapp and their results were published in a peer reviewed journal in 1987. They included elevated rates of Myelogenous Leukemia – a type of cancer most likely to be triggered by exposure to

radiation.⁹² This led to a case-control study carried out by the Massachusetts Department of Public Health that showed a four fold increase in adult Leukemia between 1978 and 1983. The report stated, "a dose-response relationship was observed in that the relative risk of leukemia increased as the potential for exposure to plant emissions also increased."⁹³

Massachusetts Department of Health Southeastern Massachusetts Health Study 1990

The Massachusetts Department of Health's own case-controlled study, *The Southeastern Massachusetts Health Study* [published in the *Archives of Environmental Health*, Vol. 51, p.266, July-August 1996] found a four-fold increase in adult leukemia the closer one lived or worked to the Pilgrim NPS.

Recommendations Made by MDPH's Southeastern Massachusetts Study- Status

1. Implement a system of real-time monitoring of radionuclide emissions so that reliable and timely data are available by which exposure can be assessed more precisely. The Sage System was put in place for public relations purposes not for its effectiveness. It consisted of 14 monitors on the edge of Pilgrim's property, too close, and MDPH did not analyze or make the data public. MDPH within the past few years took over the Sage System (now Evinet) started in earnest to work on the 1990 SMHS monitoring recommendation – see following monitoring section.
2. Develop and implement a state air quality standard more stringent than that currently in use by federal regulatory agencies and other states. The air quality standard was too high and not enforced.
3. DPH survey cancer occurrence in the Plymouth area through data collected by the Massachusetts Cancer Registry. Massachusetts Cancer Registry data is available however the Registry does not have data refined to see patterns of disease at the neighborhood level and there is no registry for birth defects and reproductive disorders.
4. Based upon the availability of resources, interviews of the families of childhood leukemia cases be conducted. Not done

Denial: Response to MDPH's Southeastern Massachusetts Health Study

The Southeastern Massachusetts Health Study was conducted, peer reviewed, and made public during the Dukakis Administration. The department (MDPH) began the process to address the first two recommendations – monitoring and establishing a more conservative radioactive air emission standard. However, there was a complete about face in November 1990 when Governor Weld took office. December 1990, Governor Weld sent his Executive Secretary to accompany Pilgrim's Vice President and Pilgrim's Health Physicist to visit Massachusetts' Interim Commissioner of Public Health, David Mulligan.

⁹²An epidemiological analysis of five towns around Pilgrim shows a 60 percent increase in leukemia rate, excluding leukemias not caused by radiation exposure. - Dr. Sidney Cobb, et.al. *Lancet*, 1987. The rate of myelogenous leukemia (the type most likely to be triggered by exposure to radiation) among males in the 5 towns around the Pilgrim reactor was found to be 2 1/2 times greater than the statewide average. *Leukemia in Five Massachusetts Coastal Towns*, Dr. Sydney Cobb, et al., Abstract for the American Epidemiologic Society, March 18, 1987; and *Leukemia near Massachusetts Nuclear Power Plant*, letter, Clapp, R.W., Cobb, S, Chan, C.K., Walker, B., *Lancet* 1987;2:1324-5.

⁹³Adults living and working within ten miles of the Pilgrim reactor had a fourfold increased risk of contracting leukemia between the years of 1978 and 1983 when compared with people living more than 20 miles away, according to a 1990 study by the Massachusetts Department of Public Health. *Southeastern Massachusetts Health Study 1978-1986*, Morris, M.S., Knorr, R.S., Massachusetts Department of Health, Southeastern Massachusetts Health Study, Oct., 1990. *Archives of Environmental Health*, Vol. 51, p266, 1996, July-Aug. #4

At that meeting Pilgrim gave their wish list. Pilgrim, the implicated industry, would be allowed to appoint a second peer review panel to re-review the Southeastern Massachusetts Health Study; and, until their own peer review panel decided whether the study was credible all the study's recommendations would be put on hold.

The second peer review panel could find nothing wrong with the study's methodology. The re-review panel stated clearly in their Executive Summary that, "The [original SMHS] study team adhered to generally accepted epidemiologic principles..." and "the findings of the SMHS cannot be readily dismissed on the basis of methodology errors or proven biases..." But somehow they just couldn't believe it - given Pilgrim's emissions. However for emissions data, they relied on data collected and provided by Pilgrim - not surprisingly it indicated that Pilgrim hardly emitted any radiation.

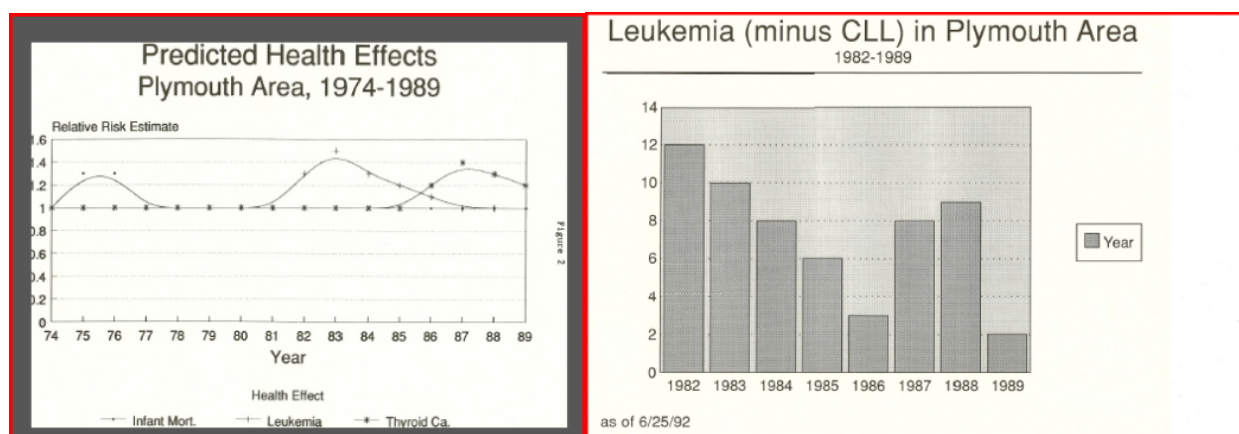
The story gets worse. Massachusetts Department of Public Health allowed Pilgrim, the implicated industry, to provide all the sound bites, press releases and public announcements about the re-review's findings, and refused to let their employees, who conducted the original study, speak to the press. Once again, we see political science used to re-write real science on behalf of industry.

Southeastern Massachusetts Childhood Leukemia Study - Mass. Dept. Public Health

The study was funded and in the planning phase, 2002. However, the project was cancelled because funds appropriated were insufficient to perform a study that would be statistically significant.

Subsequent reviews of the MA Cancer Registry show the "footprints" of radiation linked disease in communities impacted by Pilgrim.

Evidence of radiation-linked disease continued. In a statement before the Southeastern Massachusetts Health Study Review Committee [June 26, 1992] Dr. Richard W. Clapp, the founder and former director of the Massachusetts Cancer Registry, presented a graphical assessment of the pattern of leukemia and thyroid cancer in the towns closest to Pilgrim during the period 1982-1989 and an *Analysis of 1974-1989 Massachusetts Cancer Registry for Leukemia & Thyroid Cancer*, Dr. Richard Clapp, DSc, MPH (2006), *personal communication*.

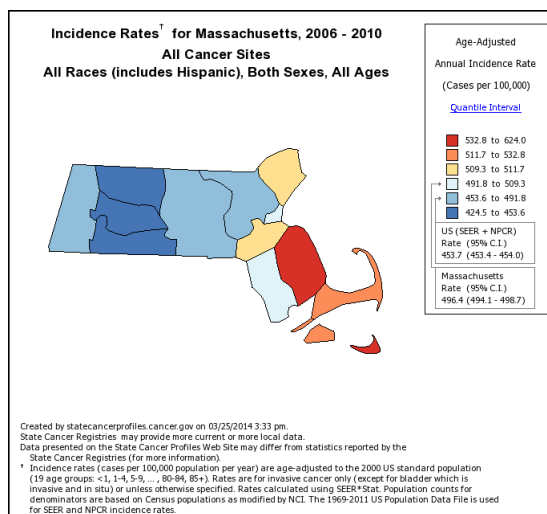


The graphs of the incidence leukemia and thyroid cancer in the Plymouth area show that the incidence of leukemia peaked in 1982 and subsequently declined until 1986. Then there was a second, smaller peak in 1987 and 1988 while declined in 1989. The number of cases exceeded the number expected in

1982-85 and 1987-88. The second graph depicts the pattern of thyroid cancer in the same set of towns. It shows a peak in the years 1987-1988. These patterns of cancer incidence are consistent with the predicted health effects of the radiation released in the early 1980s. A graph showing the predicted health effects is also shown in Exhibit F. A statistically significant increase in childhood leukemia was noted in communities near Pilgrim, too. Although Massachusetts Department of Public Health recommended a state sponsored case-controlled childhood leukemia study, it was not done.

The Massachusetts Cancer Registry also shows, for the years 1998-2002, a continuing increase of leukemia and thyroid cancer in the towns around PNPS. Specifically, there were 83 cases of leukemia reported to the Massachusetts Cancer Registry (MCR), where 72.9 would have been expected based on statewide rates. This results in a Standardized Incidence Ratio (SIR) of 114 (95% conf. int. = 91-143). In addition, there was excess thyroid cancer in these same towns for the same time period. The thyroid cancer SIR was 122 (95% conf. int. = 96-155). In other words, leukemia was 14% elevated over the statewide rate and thyroid cancer was 22% elevated. Neither of these calculations were statistically significantly elevated by the usual convention ($P < .05$), but there were more cases than expected, nevertheless. This means there is a continuing excess of these two radiation-related cancers in the population, as there was in the 1980s. *Analysis of 1998-2002 Massachusetts Cancer Registry for Leukemia & Thyroid Cancer*, Dr. Richard Clapp, 2006, personal communication.

Prostate cancer and multiple myeloma, both radiation-linked diseases, are also elevated and statistically significant for the years 1998-2002 in the seven towns most likely to be impacted near Pilgrim (Carver, Duxbury, Kingston, Marshfield, Pembroke, Plymouth, and Plympton). *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 (2006)*. Occupational Radiation Studies, Chapter 8,, National Academies Press, 2006. Specifically, data from the Massachusetts Cancer Registry indicates 613 cases of prostate cancer vs. 513.5 expected SIR=119 (95% C.I.=110-129); multiple myeloma: 47 cases vs. 31.7 expected, SIR=148 (95% C.I.=108-198). *Analysis of 1998-2002 Massachusetts Cancer Registry for Leukemia & Thyroid Cancer*, Dr. Richard Clapp, 2006, personal communication.



Radiation-linked Cancers in Towns Surrounding Pilgrim showing Statistical Significance of SIR a 95% level probability-Massachusetts Cancer Registry 2002 -2009 – examples:

Town	Leukemia	M u l t i p l e Myeloma	Prostate Cancer
Plymouth	2002-2006; 2 0 0 3 - 2 0 0 7 (female); 2 0 0 4 - 2 0 0 8 (female); 2 0 0 5 - 2 0 0 9 (female)		2002-2006; 2003-2007; 2004-2008; 2005-2009
Duxbury			2002-2006; 2003-2007; 2004-2008; 2005-2009
Kingston			2005-2009
Marshfield		2 0 0 3 - 2 0 0 7 (female)	2003-2007;2004- 2008

For further updates, visit the Massachusetts Department of Public Health's Cancer Registry - data is listed by year for each town. An updated report is due.

<http://www.mass.gov/eohhs/gov/departments/dph/programs/admin/dmoa/cancer-registry/>

Post-Accident Studies

Three Mile Island

Summary of Findings at Three Mile Island: 1979-2005

Author: Eric Epstein, Chairman, Three Mile Island Alert, October 2011 <http://www.tmia.com/taxonomy/term/12>

On March 30, 1979, Governor Richard Thornburgh recommended an evacuation for preschool children and pregnant women living within five miles of Three Mile Island ("TMI"). Data collected since the meltdown clearly demonstrate a significant nexus between radiation exposure and adverse health impacts to women and children.

A great deal of radiation was indeed released by the core melt at TMI. The President's Commission estimated about 15 million curies of radiation were released into the atmosphere. A review of dose assessments, conducted by Dr. Jan Beyea, (National Audubon Society; 1984) estimated that from 276 to 63,000 person-rem were delivered to the general population within 50 miles of TMI. David Lochbaum of the Union of Concern Scientists estimated between 40 million curies and 100 million curies escaped during the Accident.

- 1979-1988: Katagiri Health Surveys begin and involve 250 residents living around Three Mile Island. This field research documented increased cancer incidences and mortalities in population pockets exposed by radioactive plumes.
- March, 1982, *The American Journal of Public Health* reported, "During the first two quarters of 1978, the **neonatal mortality rate** within a ten- mile radius of Three Mile Island was 8.6 and 7.6 per 1,000 live births, respectively. During the first quarter of 1979, following the startup of accident prone Unit 2, the rate jumped to 17.2; it increased to 19.3 in the quarter following the accident at TMI and returned to 7.8 and 9.3, respectively, in the last two quarters of 1979." (**Dr. Gordon MacLeod, Secretary, Pennsylvania Department of Health**)
- Penn State Professor Winston Richards reported, "Infant mortality for Dauphin County, while average in 1978, **becomes significantly above average in 1980.**"
- 1984: The first Voluntary Community Health Study was undertaken by a group of local residents trained by Marjorie Aamodt. That study found a 600 percent cancer death rate increase for three locations on the west shore of TMI directly in the plumes' pathway. The data were independently verified by experts from the TMI Public Health Fund.
- 1985: Jane Lee surveyed 409 families living in a housing development five miles from TMI. Lee documented 23 cancer deaths, 45 cancer incidences, 53 benign tumors, 31 miscarriages, stillbirths, and deformities, and 204 cases of respiratory problems.
- By 1985, TMI's owners and builders had paid more than \$14 million for out-of-court settlements of personal injury lawsuits including \$12.250 million paid to 280 plaintiffs and **Orphans Court Cases**.
- August 1985: Marc Sheaffer, a psychologist at the Uniformed Services University of the Health Sciences in Bethesda, released a study linking TMI-related stress with **immunity impairments**.
- August 1987: Prof. James Rooney and Prof. Sandy Prince of Embury of Penn State University-Harrisburg reported that "**chronically elevated levels of psychological stress**" have existed among Middletown residents since the Accident.
- April 1988: Andrew Baum, professor of medical psychology at the Uniformed Services University of the Health Sciences in Bethesda discussed the results of his research on TMI residents in *Psychology Today*. "When we compared groups of people living near Three Mile Island with a similar group elsewhere, we found that the Three Mile Island group reported more physical complaints, such as headaches and back pain, as well as more **anxiety and depression. We also uncovered long- term changes in levels of hormones...**These hormones affect various bodily functions, including muscle tension, cardiovascular activity, overall metabolic and immune-system function..."
- James Fenwick, a researcher at Millersville University, found statistically **significant increases of kidney, renal, pelvis and ovarian cancer in women**. (April 1998)
- June 1991: Columbia University's Health Study (Susser-Hatch) published results of their findings in the *American Journal of Public Health*. The study actually shows a more than doubling of all observed cancers after the accident at TMI-2, including lymphoma, leukemia, colon and the **hormonal category of breast, endometrium, ovary, prostate and testis**. For leukemia and lung cancers in the six to 12 km distance, the number observed was almost four times greater. In the 0-six km range, colon cancer was four times greater. The study found "a statistically significant relationship between incidence rates after the accident and residential proximity to the plant."

- August 1996: A study by the University of North Carolina-Chapel-Hill, authored by Dr. Steven Wing, reviewed the Susser-Hatch (Columbia University) study released in June 1991. Dr. Wing reported "...there were reports of erythema, hair loss, vomiting, and pet death near TMI at the time of the accident...**Accident doses were positively associated with cancer incidence.** Associations were largest for leukemia, intermediate for lung cancer, and smallest for all cancers combined...Inhaled radionuclide contamination could differentially impact lung cancers, which show a clear dose-related increase.
- By 1996, the plant's owners, codefendants and insurers have paid over **\$80 million** in health, economic and evacuation claims, including a \$1.1 million settlement for a baby born with Down's Syndrome.
- **Thyroid cancer**, 1995-2002: Dr. Roger Levin, chief division of otolaryngology/head and neck surgery, PinnacleHealth System in Harrisburg, and clinical associate professor of surgery, Penn State College of Medicine. Findings: In reviewing state health data, Levin found **more thyroid cancer cases than expected in York County for every year except one between 1995 and 2002.** One plausible reason could be people were exposed to radiation during the 1979 Three Mile Island accident, he said.

For a analysis of what happened at TMI see <http://www.fairewinds.org/nuclear-energy-education/writing-the-nuclear-meltdown-playbook>

Chernobyl

There is a huge disparity in reports on the health impacts that resulted from the Chernobyl disaster.

The most authoritative report is **Chernobyl Consequences Of The Catastrophe For People And The Environment**, Alexey V. Yablokov, Vassily B. Nesterenko, Alexey V. Nesterenko, Annals of the New York Academy of Sciences, Vol 1181. (http://www.strahlentelex.de/Yablokov_Chernobyl_book.pdf; and video Summarizing the book <http://blip.tv/envirovideo/chernobyl-a-million-casualties-4940000>) The report **estimated 985,000 died from 1986-2004 as a result of the accident** based on over 5,000 articles from doctors and scientists who had "boots on the ground." The human health effects ran the gamut from cancers, heart disease, genetic damage, reproductive disorders and birth defects. Every organ in the body showed damage. The report also looked at damage to the environment- birds, fish, insects, large and small animals, and vegetation. Impacts were most severe in Belarus, Russia and Ukraine; but the impact was not limited there because radiation spread around the world.

The International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) are often quoted but their report severely downplayed the impacts. They relied upon a relatively small number of studies (about 4,000 in the English language) and only studies of populations exposed to the highest exposures and failed to take account of those exposed to less but harmful levels of radiation.

This is perhaps not surprising. As discussed below, the IAEA was formed to both promote and regulate the nuclear industry around the world. WHO and the IAEA made an agreement that neither would publish a report absent the approval of the other. The NRC and industry also have downplayed the impact of the Chernobyl disaster.

WHO and IAEA (<http://www.beyondnuclear.org/home/2011/3/21/world-health-organizations-toxic-link-to-iaea.html>)?

Fifty years ago, on 28 May 1959, the World Health Organization's assembly voted into force an obscure but important agreement with the International Atomic Energy Agency – the United Nations "Atoms for Peace" organization, founded just two years before in 1957. The effect of this agreement has been to

give the IAEA an effective veto on any actions by the WHO that relate in any way to nuclear power – and so prevent the WHO from playing its proper role in investigating and warning of the dangers of nuclear radiation on human health.

The WHO's objective is to promote "the attainment by all peoples of the highest possible level of health", while the IAEA's mission is to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". Although best known for its work to restrict nuclear proliferation, the IAEA's main role has been to promote the interests of the nuclear power industry worldwide, and it has used the agreement to suppress the growing body of scientific information on the real health risks of nuclear radiation.

Under the agreement, whenever either organization wants to do anything in which the other may have an interest, it "shall consult the other with a view to adjusting the matter by mutual agreement". The two agencies must "keep each other fully informed concerning all projected activities and all programs of work which may be of interest to both parties". And in the realm of statistics – a key area in the epidemiology of nuclear risk – the two undertake "to consult with each other on the most efficient use of information, resources, and technical personnel in the field of statistics and in regard to all statistical projects dealing with matters of common interest".

The language appears to be evenhanded, but the effect has been one-sided. For example, investigations into the health impacts of the Chernobyl nuclear accident in Ukraine on 26 April 1986 have been effectively taken over by IAEA and dissenting information has been suppressed. The health effects of the accident were the subject of two major conferences, in Geneva in 1995, and in Kiev in 2001. But the full proceedings of those conferences remain unpublished – despite claims to the contrary by a senior WHO spokesman reported in *Le Monde Diplomatique*.

Meanwhile, the 2005 report of the IAEA-dominated Chernobyl Forum, which estimates a total death toll from the accident of only several thousand, is widely regarded as a whitewash as it ignores a host of peer-reviewed epidemiological studies indicating far higher mortality and widespread genomic damage. Many of these studies were presented at the Geneva and Kiev conferences but they, and the ensuing learned discussions, have yet to see the light of day thanks to the non-publication of the proceedings.

The British radiation biologist Keith Baverstock is another casualty of the agreement, and of the mindset it has created in the WHO. He served as a radiation scientist and regional adviser at the WHO's European Office from 1991 to 2003, when he was sacked after expressing concern to his senior managers that new epidemiological evidence from nuclear test veterans and from soldiers exposed to depleted uranium indicated that current risk models for nuclear radiation were understating the real hazards.

Now a professor at the University of Kuopio, Finland, Baverstock finally published his paper in the peer-reviewed journal *Medicine, Conflict and Survival* in April 2005. He concluded by calling for "reform from within the profession" and stressing "the political imperative for freely independent scientific institutions" – a clear reference to the non-independence of his former employer, the WHO, which had so long ignored his concerns.

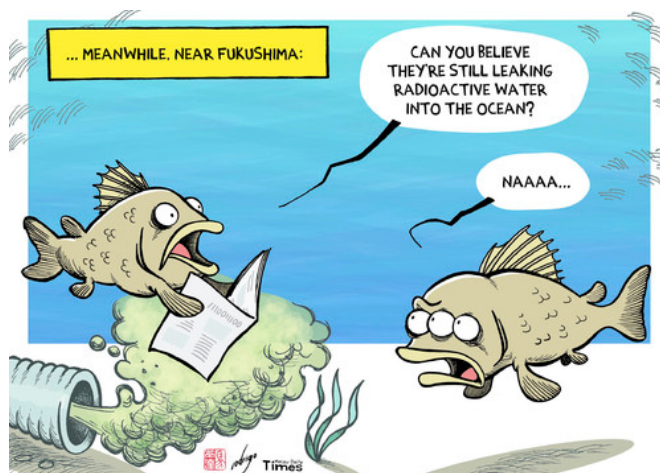
Since the 21st anniversary of the Chernobyl disaster in April 2007, a daily "Hippocratic vigil" has taken place at the WHO's offices in Geneva, organised by Independent WHO to persuade the WHO to abandon its the WHO-IAEA Agreement. The protest has continued through the WHO's 62nd World Health Assembly, which ended yesterday, and will endure through the executive board meeting that begins today. The group has struggled to win support from WHO's member states. But the scientific case against

the agreement is building up, most recently when the European Committee on Radiation Risk (ECRR) called for its abandonment at its conference earlier this month in Lesvos, Greece.

At the conference, research was presented indicating that as many as a million children across Europe and Asia may have died in the womb as a result of radiation from Chernobyl, as well as hundreds of thousands of others exposed to radiation fallout, backing up earlier findings published by the ECRR in Chernobyl 20 Years On: Health Effects of the Chernobyl Accident. Delegates heard that the standard risk models for radiation risk published by the International Committee on Radiological Protection (ICRP), and accepted by WHO, underestimate the health impacts of low levels of internal radiation by between 100 and 1,000 times – consistent with the ECRR's own 2003 model of radiological risk (The Health Effects of Ionising Radiation Exposure at Low Doses and Low Dose Rates for Radiation Protection Purposes: Regulators' Edition).

According to Chris Busby, the ECRR's scientific secretary and visiting professor at the University of Ulster's school of biomedical sciences: "The subordination of the WHO to IAEA is a key part of the systematic falsification of nuclear risk which has been under way ever since Hiroshima, the agreement creates an unacceptable conflict of interest in which the UN organisation concerned with promoting our health has been made subservient to those whose main interest is the expansion of nuclear power. Dissolving the WHO-IAEA agreement is a necessary first step to restoring the WHO's independence to research the true health impacts of ionising radiation and publish its findings." (Source: Beyond Nuclear)

Fukushima



The health impacts from Fukushima will need to be assessed for several decades. The World Health Organization (WHO) - which cannot pronounce on things nuclear without ceding to the nuclear-promoting International Atomic Energy Agency (IAEA)⁹⁴ - predictably downplayed the likely health impacts resulting from the Fukushima nuclear disaster. The Japanese government went even further, suggesting the WHO over-stated the likely impacts. Fundamentally, the WHO found, after a two-year

⁹⁴ <https://www.nirs.org/radiation/whoiaeastatment.pdf>

study, that "the risk for certain types of cancers had increased slightly among children exposed to the highest doses of radioactivity, but that there would most likely be no observable increase in cancer rates in the wider Japanese population." However, the agency was at least forced to admit that "their assessment was based on limited scientific knowledge; much of the scientific data on health effects from radiation is based on acute exposures like those that followed the bombing of Hiroshima and Nagasaki and not chronic, low-level exposure."



Pictured is the former mayor of Futaba, Fukushima Daiichi's host town, now a radioactive ghost town. Before the catastrophe, he was pro-nuclear. Now, he is an outspoken anti-nuclear leader.

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Thyroid Cancer: A 2015 Japanese study that analyzed prefecture data on childhood leukemia up to December 31, 2014, published in the November 2015 issue of *Epidemiology* says that children living near the Fukushima nuclear meltdowns have been diagnosed with thyroid cancer at a rate 20 to 50 times that of children elsewhere, a difference the authors contend undermines the government's position that more cases have been discovered in the area only because of stringent monitoring⁹⁶.

The highest incidence rate ratio was among people whose district was not evacuated, 50 to 60 km (30 to 40 miles approximately) west from the Fukushima nuclear reactors. Data show 605 thyroid cancer cases per million examinees. The expected cases of thyroid cancer for children is 1-2 per year per million. Ground contamination does not necessarily reflect exposure. Some of the most exposed people came from areas where radionuclide deposition was minimal, but *radioactive iodine in the air as a result of the catastrophe still exposed them*.

The magnitude of the increase is too great to be explained by increased screening since available data show a 2 to 3- and at most a 6 to 7-fold increase would be attributable to enhanced screening efforts. The data examined by Tsuda, the study's chief author, show cancer cases an order of magnitude higher.

The cancers found by this screening in Fukushima prefecture had metastasized to lymph nodes in 74% of cases (40 cases out of 54), meaning these cancers were not in early stages of development. Therefore,

⁹⁵ <http://www.beyondnuclear.org/home/2013/3/5/who-predictably-downplays-fukushima-health-impacts-japanese.html>

⁹⁶ <http://www.beyondnuclear.org/home/2015/10/8/new-study-claims-a-30-fold-increase-in-thyroid-cancer-in-fuk.html>; and, http://www.nytimes.com/aponline/2015/10/08/world/asia/ap-as-japan-nuclear-childrens-cancer.html?_r=0 (AP, NYT, October 8, 2015)

when interpreting the data, overtreatment is also not an issue; a conclusion shared by doctors who helped treat these patients.

Contrary to claims that we would not be seeing an increase in cancers this early (within a year after exposure to radioactivity), radioactivity from Fukushima could have caused this increase in thyroid cancers because excess cancers were observed subsequent to Chernobyl in the earlier years. Further, the US CDC recognizes a minimum empirical induction time for thyroid cancer of 2.5 years in adults; and 1 year in children for all cancers including thyroid. The minimum latency for leukemia is 0.4 years (146 days).

The Japanese study concludes: "In Chernobyl, excesses of thyroid cancer became more remarkable 4 or 5 years after the accident in Belarus and Ukraine, so the observed excess alerts us to prepare for more potential cases within a few years. Furthermore, we could infer a possibility that exposure doses for residents were higher than the official report or the dose estimation by the World Health Organization, because the number of thyroid cancer cases grew faster than predicted in the World Health Organization's health assessment report."

Earlier studies, 39 months after the three explosions at Fukushima, showed thyroid cancer rates among children living nearby increased to more than forty times (40x) normal. More than 48 percent of some 375,000 young people—nearly 200,000 kids—tested by the Fukushima Medical University near the reactors now have pre-cancerous thyroid abnormalities, primarily nodules and cysts. The nuclear industry and its apologists continue to deny these health effects. However the findings are consistent with impacts suffered among children near the 1979 accident at Three Mile Island and the 1986 explosion at Chernobyl, as well as findings at other commercial reactors.

The truth is that we not do not have sufficient data to provide accurate information on the long-term impact. The reactors continue to release radiation and the cores have not been examined to make accurate exposure predictions. What we can say, though, is that there are very likely to be very significant long-term health impact from prolonged exposure.



To learn more, see: Dr. Helen Caldicott's March 11 and 12, 2013 NYC symposium, "The Medical and Ecological Consequences of the Fukushima Nuclear Accident," is now viewable online at <http://www.totalwebcasting.com/view/?id=hcf#> Presenters include:

Alexey Yablokov, Russian Academy of Sciences

Lessons from Chernobyl

Wladimir Wertelecki, Former Chair of the Department of Medical Genetics University South

Alabama

Congenital Malformations in Rivne Polossia and the Chernobyl Accident

Ian Fairlie, Radiation Biologist and Independent Consultant

The Nuclear Disaster at Fukushima: Nuclear Source Terms, Initial Health Effects

Steve Wing, Gillings School of Public Health, University North Carolina

Epidemiological Studies of Radiation Releases from Nuclear Facilities: Lessons Past and Present

Joe Mangano, Radiation and Public Health Project

Post Fukushima Increases in Newborn Hypothyroidism on the West Coast of USA

Robert Alvarez, Institute for Policy Studies

Management of Spent Fuel Pools and Radioactive Waste

International Studies

Childhood Leukemia Doubled Around French and German Reactors

A major epidemiological study published in the January 2012 edition of [The International Journal of Cancer](#) indicates there is “a possible excess risk” of acute leukemia among children living in close vicinity to French nuclear power plants (NPP). The study called for an “investigation for potential risk factors related to the vicinity of NPP, and collaborative analysis of multisite studies conducted in various countries.”

The study found a doubling of occurrence of childhood leukemia between the years of 2002-2007 among children under 5 years living within 5 km of nuclear plants – similar to the findings of the [German 2008 study](#) by the Cancer Registry in Mainz which found an association between the nearness of residence to nuclear power plants and the risk of childhood leukemia.

The epidemiological study was conducted by a team from the Institut National de la Santé et de la Recherche Médicale, the Institut de Radioprotection et de Sûreté Nucléaire (IRSN) and the National Register of hematological diseases of children in Villejuif.

The German affiliate of the International Physicians for the Prevention of War published an analysis that showed a possible mechanism to explain the leukemia clusters close to German and French nuclear power plants.

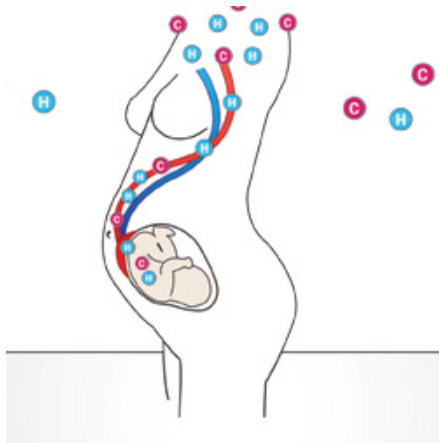


Image courtesy of German IPPNW - [The German affiliate of International Physicians for the Prevention of Nuclear War has published analysis](#) showing large releases of radioactivity during "routine" re-fueling of atomic reactors in Bavaria. The releases are hundreds of times higher than what is considered a "normal" release. The German IPPNW warns that fetuses would

be especially vulnerable to these radioactive hazards. This physical, chemical, and biological delivery mechanism of radioactivity into fetal tissue is one possible explanation for statistically significant increases in childhood leukemia rates detected near nuclear power plants by German and French government health studies, which officially have "no explanation."

To learn more see: Childhood Leukemias Near Nuclear Power Stations, [July 25, 2014](#)

<http://www.ianfairlie.org/news/childhood-leukemias-near-nuclear-power-stations-new-article/>;
Commentary: childhood cancer near nuclear power stations, [Ian Fairlie](#), Environmental Health 2009,
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2757021/>; Childhood cancers near German nuclear power stations: hypothesis to explain the cancer increases, [PreviewView full textDownload full text](#)

Methodology- Studying Radiation Health Impacts

Dr. Busby recommends that in nuclear epidemiology: First, studies of adult cancer around nuclear sites should focus on common cancers like breast cancer, or indeed multiple cancers because there is more statistical power than rare cancers like leukemia.

Second, in such 'ecological studies' (where a region is taken as a surrogate for an exposure) the groups must be chosen because of determining where the radioactivity ends up, and not through some primitive circle drawing exercise. His article advises that this is an important message to the US Nuclear Regulatory Commission (NRC) who have been mulling over protocols for examining risk near US nuclear sites for several years now since they were bounced into it by pressure brought to bear on Congress by those people living near the nuclear sites, who can see what is happening to them and their friends. See: *Statistics Reveal the Link They Wanted to Hide: Breast Cancer and Nuclear Sites*, Dr. Chris Busby, May 19, 2015 at [HTTP://WWW.COUNTERPUNCH.ORG/2015/05/19/BREAST-CANCER-AND-NUCLEAR-SITES/](http://WWW.COUNTERPUNCH.ORG/2015/05/19/BREAST-CANCER-AND-NUCLEAR-SITES/)

Also case-controlled studies, like the Massachusetts Southeastern Massachusetts study, are far stronger than statistical studies.

MONITORING: RADIATION RELEASES

We need monitoring during operations and after operations cease



Radioactive Air Emissions Offsite

NRC Regulations: NRC regulations require the licensee to have in place an effective program for monitoring radiation on-site and off-site: the release of unmonitored material is against regulation.⁹⁷

10 CFR § 20.1302 and §50 Appendix A Criterion 60 require NRC's licensee to demonstrate that effluents, including those from 'anticipated operational occurrences,' do not expose members of the public to excessive radiation doses. Effective monitoring systems are required in order to comply with these regulations, Criterion 64.

How to find reports on routine radioactive releases from each nuclear power plant

Each commercial nuclear power plant is required to submit two annual reports, which detail (1) the radioactive effluents discharged from the site, and (2) the effects (if any) on the environment. In addition to these two annual reports, in 2007 each power plant voluntarily submitted answers to a questionnaire related to the voluntary initiative on groundwater protection, initiated by the commercial nuclear power industry. To see these reports and questionnaires for a nuclear power plant, see <http://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html> Select the plant name from the table.

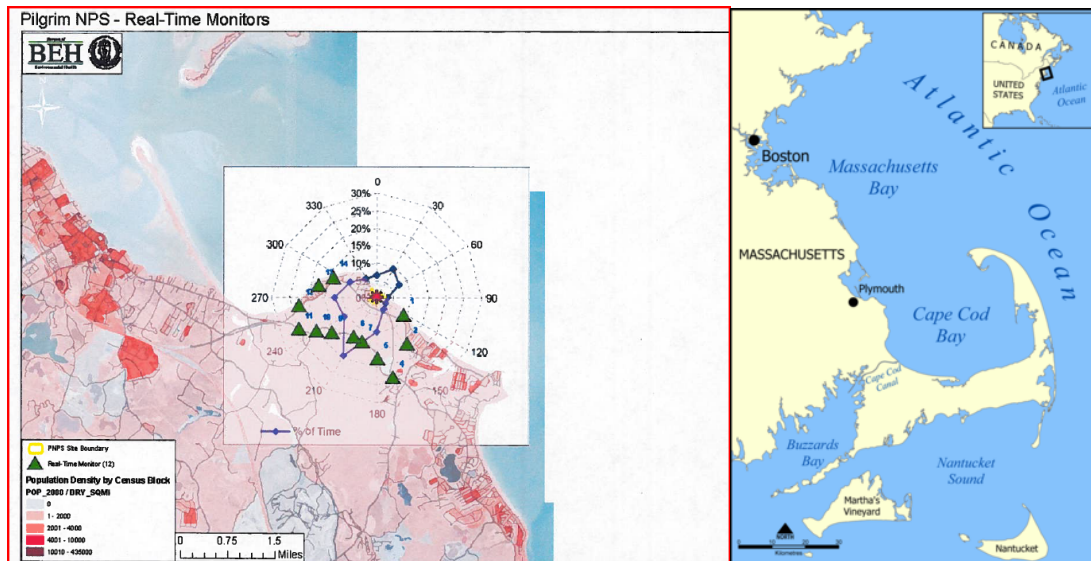
Importance Monitoring Air Emissions for Emergency Planning & Health Studies: It is important that additional/enhanced offsite real-time or minute-by-minute meteorological and radiological monitoring is done by the State and that the data is reported to the public. **Forecasting:** It would provide a tool to use ahead of time for emergency pre-planning to understand where a plume would likely go under various typical weather regimes, and what and where the resultant concentrations/potential doses could be. **Now-casting:** It would be important during a radiological emergency to know where the plume actually is going and resultant concentrations/potential doses required for making appropriate recommendations (i.e., evacuate or shelter in place). **Hindcasting:** It would be important for the post-radiological emergency timeframe. Combining meteorological modeling with expanded meteorological/radiological data to provide for more accurate/realistic dose estimates can help with disaster recovery, cleanup, litigation resolution, and short-term acute and long-term epidemiological health studies. **Neighborhood Watch:** If the licensee knows that it is being watched, it is motivated to take extra care.

Status Mass. Department Of Public Health Air Monitoring System

⁹⁷ **NRC's Liquid Radioactive Release Lessons Learned Task Force, Final Report**, September 1, 2006, Section 3.2.1.2, Existing Regulatory Framework. **10 CFR § 20.1302 Compliance with dose limits for individual members of the public:** (a)(b) **10 CFR § 50 Appendix A: Criterion 60--Control of releases of radioactive materials to the environment.** The nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences. Sufficient holdup capacity shall be provided for retention of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment. **Criterion 64--Monitoring radioactivity releases.** Means shall be provided for monitoring the reactor containment atmosphere, spaces containing components for recirculation of loss-of coolant accident fluids, effluent discharge paths, and the plant environs for radioactivity that maybe released from normal operations, including anticipated operational occurrences, and from postulated accidents.

Monitors	Effective Real-time Air Monitoring System Includes	MDPH's System 2012
Location	- Monitors placement must be based on prior meteorological analysis. - Monitors ring the reactor, including placement in <u>all</u> (5) Emergency Planning Zone (EPZ) towns and Cape Cod, <u>at minimum</u>. - Monitors in near-field placed at sufficient distance from potential release points on site to maximize detection. - Monitors placed in a double ring in order to gauge penetration of the plume inland.	(12) Located ½ to 1 ½ miles from site in small quadrant behind plant <u>2013 additions:</u> (1) placed at the Gurnet Point, Plymouth; (1) placed in downtown Plymouth, (1) placed at shopping mall (Colony Place) Rt. 44, Plymouth <u>Town of Duxbury</u> Annual Town Meeting appropriated \$18,000 to purchase a monitor for Duxbury to integrate in MDPH's system
Number	22 at minimum as originally promised in the early 1990's	15
Detection Capability	Gamma, alpha, beta radionuclides & weather data -precipitation, wind direction, speed	Gamma radiation; precipitation, one monitor
Data Linked	Data linked to Massachusetts Department of Public Health (MDPH), Massachusetts Emergency Management Agency (MEMA), Local Emergency Operation Centers	Linked to MDPH and MEMA
Public Availability	Data live-streamed on MDPH's website; monthly summary reports provided on MDPH's website & concurrently forwarded to the designated State/Local officials; annually reported in the licensee's Radiological Environmental Monitoring Program report to NRC. If a reading is above a pre-determined base level for a pre-determined sustained period of time, notification to designated state/local officials made before the end of the next business day according to a pre-announced protocol, determined with public input.	Public notification envisioned to begin Fall 2012, not yet made available
Cost	Monies come out of section 5K of chapter 111 of the General Laws that provides the department may expend not more than \$180,000 from assessments collected under section 5K for services provided to monitor , survey and inspect nuclear power reactors	Originally \$18,000 each monitor (purchase price and installation)- now \$44,000

Location of MDPH Monitors



The monitors are located $\frac{1}{2}$ mile to $1 \frac{1}{2}$ miles from the reactor. They are too close together; equipment is wasted and should be relocated further afield. For example, the Southeastern Massachusetts Health Study and subsequent studies by Dr. Clapp, founder, and former director of the Mass Cancer Registry, showed radiation-linked effects in populations well beyond $1 \frac{1}{2}$ miles. There are no monitors in the direction of where 60% of the prevailing winds, according to Entergy, shown immediately below. (Source: Testimony of Dr. Kevin R. O’Kula and Dr. Steven R. Hanna on Meteorological Matters Pertaining to Pilgrim Watch Contention 3, Entergy Exhibit 00001, Pilgrim LRA Proceeding, 50-293-LR, 06-848-02-LR, January 3, 2001)

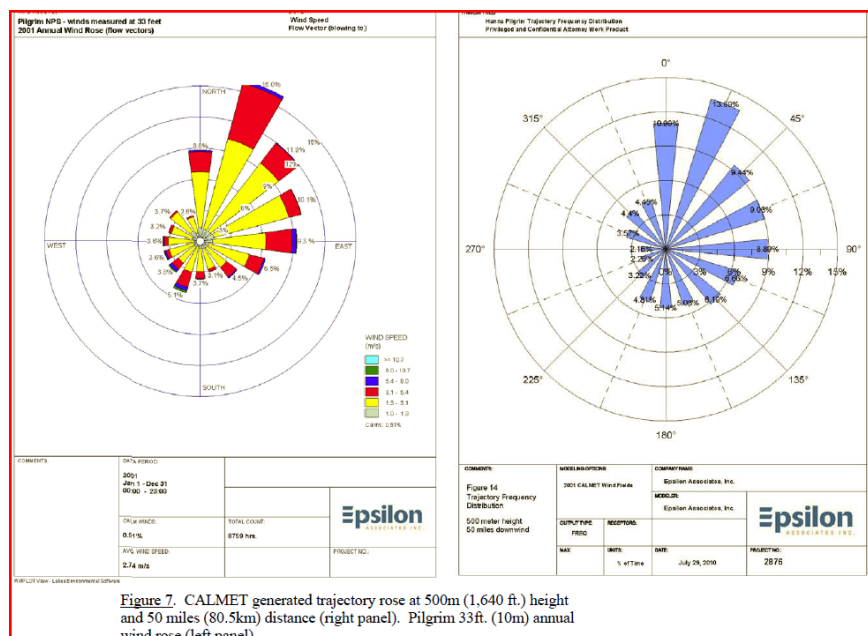


Figure 7. CALMET generated trajectory rose at 500m (1,640 ft.) height and 50 miles (80.5km) distance (right panel). Pilgrim 33ft. (10m) annual wind rose (left panel).

Additional monitors were added further afield: Downtown Plymouth; Colony Plaza, West Plymouth (Route 44); Gurnet, located south end Duxbury Beach; Mattakesett Court Duxbury, monitor provided by Town of Duxbury. More are needed. A few have a meteorological component.

Funding Program: The money comes out of section 5K of chapter 111 of the General Laws that provides the department may expend **not more than \$180,000** from assessments collected under section 5K for services **provided to monitor**, survey and inspect nuclear power reactors. The assessment should be increased. H.1133, a pending bill (2017) in the General court, amends Ch 111, 5K (E) to increase licensee assessments for MDPH's environmental monitoring from \$180,000 a year (set in 1992) to \$500,000.

Radioactive Liquids Leaking Offsite

Leaks of radioactive contaminated liquid into the ground from buried components at U.S. nuclear reactors have occurred with increased frequency. Many of these leaks were initially undetected and remained undetected for many years. In at least one case, the leak was not detected until after an underground plume of several million gallons of contaminated water traveled beyond the nuclear facility's site into drinking wells. In most cases, the leak was finally detected, more by happenstance than by rigorous monitoring. In all cases, a small leak undetected for an extended period permitted large amounts of contaminated water to enter the ground around the facilities.

Better prevention and monitoring systems are needed. Unmonitored leaks of radioactive materials offsite are against NRC regulation; a public health hazard; a threat to local fishing and aquaculture; and may significantly increase the monies needed to decommission the reactor beyond what the owner set aside, sticking added costs to citizens.

Tritium, What Is It? Tritium, a radioactive form of hydrogen, is a gas in its elemental form. Like ordinary hydrogen, tritium combines with oxygen to make water, called tritiated water. Tritiated water is radioactive. Tritiated water is chemically identical to normal water and tritium cannot be filtered out of the water.

Where Does It Come From? Natural: There is some natural background tritium in surface and groundwater that comes from the interaction of cosmic radiation with the atmosphere. These levels are very low – typically 5 to 25 picocuries per liter in surface water and less than 6.4 to 12.8 picocuries per liter in groundwater. **Weapons:** Large amounts were added in the atmosphere and global waters from atmospheric testing of nuclear weapons. However the last atmospheric test was by China in 1980; and since the half-life of tritium is 12.3 years, most of the additions due to testing have decayed away. **Nuclear Reactors:** Nuclear reactors generate tritium in the course of their operation and release it both to the atmosphere and to water bodies. Under normal reactor operating conditions, most of the tritium (H-3) gas is produced and released routinely to the atmosphere comes from reactor spent fuel pool. The pools are estimated to be the largest source of atmospheric tritium releases to the environment.⁹⁸ Tritium gas release increases as more spent fuel is added and stored for several years. Fuel cladding defects and the release of irradiated water from the containment in the spent fuel pool during refueling also increases tritium levels. Overheating of the spent fuel pool could generate radioactive vapors that threaten the habitability of working areas. spent fuel pool evaporation as the major/primary source of tritium released in gaseous form from ground-level points.

⁹⁸ Jason T. Harris, Tritium Releases from Nuclear Power Plants, Idaho State University, July 24, 2012, http://hpschapters.org/sections/envrad/2012AMPresentations/Harris%20HPS%20Tritium_2012.pdf

How Do People Become Exposed To Tritium? Tritium is almost always found as a liquid and primarily enters the body when people eat, or drink food or water containing tritium or absorb it through their skin. People can also inhale tritium as a gas in the air.

What Are The Health Risks? As radioactive water, tritium can cross the placenta, posing some risk of birth defects and early pregnancy failures. Ingestion of tritiated water also increases cancer risk.

How Much Is Considered Safe? Standards for tritium in drinking water range from 20,000 picocuries per liter in drinking water to 400 picocuries.

- EPA: EPA's standard for tritium in drinking water is 20,000 picocuries per liter.
- Ontario Canada's Drinking water quality standard for tritium is 540 picocuries per liter.
- California's recommended public health goal for tritium in drinking water is 400 picocuries per liter.
- The Department of Energy agreed to an action level of 500 picocuries per liter for tritium in surface water in the clean up at Rocky Flats - a level corresponding to Colorado's standard for tritium in surface water.

Therefore when reactor owners and the NRC dismiss public concerns about leaks, saying that tritium levels measured offsite by the plant operators were well below the EPA drinking water standard of 20,000 picocuries per liter and are "safe. This is not correct because: All radiation protection regulations and the most recent report of the National Academies BEIR VII report concluded that the hypothesis that best fits the facts is that every exposure to radiation produces a corresponding cancer risk – low exposures produce low risk, and that risk increases with exposure. There is no threshold below which there is zero risk. The EPA's method of expressing this reality is to set a Maximum Contaminant Level Goal (MCLG) which corresponds to zero health risk. The EPA value for MCLG for all radionuclides, including tritium, is zero.

What are NRC's Reporting Requirements?

Reporting Requirements for Liquid Releases: NRC's reporting requirement for a minimum detection limit, also called the Lower Limit of Detection (LLD), is 2,000 picocuries per liter that can be increased to 3,000 picocuries per liter if no drinking water pathway exists. NRC believes that this is satisfactory because the EPA drinking water standard (20,000 picocuries per liter) is used as a reference. But it is quite unsatisfactory if the California public health goal (400 picocuries per liter) is the reference value. Evidently, for a reliable conclusion that the level is below 400 picocuries per liter, the LLD required should be consistently lower than that. We believe that NRC must tighten its tritium LLD to 200 picocuries per liter or less and require the specification of the LLD.

Tritium measurements are done quarterly, with composite samples that are collected at various intervals, commonly monthly. This means that samples from the times tritium is discharged (many times each quarter) and the times that it is not, are put together and averaged to give a quarterly result.

There are problems with this approach. There is generally no independent verification by the NRC of when the samples are actually taken. The NRC (and hence the public) depend on the reactor operators' word that they are taken at the time of contaminated water discharge and not just before or well after. As a result, there is no verification of how representative the samples are and hence of the accuracy of the data in providing estimates of total tritium releases. If the samples are not coordinated with plant

discharges occurring over a period of time and are not fully representative of the discharges, the estimates of total tritium discharges made using the results could be inaccurate. There is at present no independent way for communities and the public to verify what is occurring in terms of discharges measurements and reporting of the same.

Reporting Requirements for Gaseous discharges: As discussed in the foregoing, rainfall episodes that occur during gaseous discharge events result in the rainfall becoming contaminated with tritium. Despite the fact that such contamination could reach high levels under certain weather and tritium release conditions, data for rainfall near reactors are not part of the Environmental Reports filed by nuclear power plant operators. The NRC does not require rainwater monitoring nor monitoring of groundwater and surface water that may be affected by contaminated rainfall events.

How Releases Are Monitored? NRC requires monitoring wells only if the groundwater onsite is used for drinking by the licensee; otherwise it is voluntary. In response to the proliferation of leaks from reactors around the country, especially at Braidwood NPS in Illinois where tritium leaks ended up in offsite drinking water, the NRC formed a Task Force in 2006. The task force's findings and the NRC's response are available on the NRC Web site at: <http://www.nrc.gov/reactors/operating/ops-experience/grndwtr-contam-tritium.html>. NRC allowed industry to develop a voluntary NEI initiative instead of establishing a regulation.

Tritium In Pilgrim's Groundwater Monitoring Wells

Tritium leaks mean a more expensive cleanup-more decommissioning money set aside

Massachusetts Department of Public Health describes its groundwater monitoring program on its website <http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/radiation/environmental-monitoring.html>)

The Tritium in Groundwater Monitoring Wells at Pilgrim Nuclear Power Station (PNPS)

The Nuclear Energy Institute proposed in 2006 that nuclear power plants begin a voluntary groundwater protection initiative aimed at monitoring for tritium in groundwater. This was prompted by tritium found in groundwater near several operating nuclear power plants in the United States. In response to this voluntary initiative, Entergy began monitoring for tritium in groundwater in 6 monitoring wells at Pilgrim Nuclear Power Station (PNPS) in Plymouth, MA in 2007. Massachusetts Department of Public Health (MDPH) officials were provided with the monitoring results of tritium in groundwater from these wells.

In response to tritium in groundwater findings at the Vermont Yankee Power Plant in VT, PNPS planned to install a few additional groundwater monitoring wells in May of 2010. Following discussions with MDPH scientists and MEMA officials, the total number of monitoring wells was increased to 12. Based on what appeared to be rising levels of tritium measured in one of these new wells (MW205), and a review of available site-specific groundwater information, MDPH recommended that Entergy install additional monitoring wells and begin collecting surface water samples immediately offshore from PNPS. In July 2010, MDPH received a report from Entergy indicating what seemed to be an unusually high level of tritium in a groundwater sample collected from MW205. That report showed 25,552 picocuries per liter (pCi/L) detected in a sample collected from MW205 on 7/7/10. At that time, MDPH representatives along with MEMA

representatives asked for increased communications and a meeting with PNPS officials to discuss the need for more frequent monitoring, regular review and discussion of groundwater data collected, and a comprehensive investigation to determine the source(s) of tritium.

In August 2010, Entergy installed 6 additional monitoring wells, increased the frequency of groundwater testing, and began surface water sampling. Since September 2010, MDPH has provided government officials and local representatives with regular updates on the tritium investigation, which has resulted in the installation of additional monitoring wells to evaluate specific sources of interest, bringing the **current total to 22 wells**.

Results of groundwater monitoring well samples collected at PNPS to date can be accessed on MDPH's website by clicking on the links in its website. Groundwater samples collected at PNPS were analyzed by an Entergy contract laboratory and split samples were analyzed by MDPH/RCP Massachusetts Environmental Radiation Laboratory (MERL). All groundwater samples were collected from groundwater monitoring wells located on the PNPS property. Approximate locations of monitoring wells are shown on the map below.



The source of elevated tritium in some monitoring wells onsite are not clear to either the licensee or MDPH. Current theories and investigations into elevated tritium levels include: the separation in the neutralization sump discharge line discovered 2013 impacting MW 218 and MW219; catch basins in the area of MW216 and MW206 that accept roof drain runoff; role of tritium in washout; an evaluation of the conductivity and dissolved oxygen in MW216; an evaluation of water migration from inside the plant to groundwater via seismic gaps between the reactor and turbine buildings; and an evaluation of the contribution of historic spills to the current level of tritium in groundwater.

Aging Management Program: Although Pilgrim's program to prevent and detect leaks in buried components has improved, it remains inadequate. It still lacks a sufficient number of monitoring wells placed in accordance with accepted design standards; lacks cathodic protection to prevent corrosion; and lacks a requirement to perform a more robust inspection program. Currently only (1) inspection that does not specify how large a sample is called for is required over the 20-year license renewal period.

Resources

- Radioactive Rivers and Rain: Routine Releases of Tritiated Water From Nuclear Power Plants, Annie Makhijani and Arjun Makhijani, Ph.D. August 2009, <http://www.ieer.org/sdfiles/16-1.pdf>
- Health Risks of Tritium: *The Case for Strengthened Standards*, Arjun Makhijani, Brice Smith, Michael C. Thorne, February 2007, <http://www.ieer.org/sdfiles/14-4.pdf>
- Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities, Dr. Ian Fairlie, June 2007, <http://www.nirs.org/radiation/tritium/tritium06122007gphazardreport.pdf>
- US. NRC, Buried Reactor Pipes & Tritium Fact Sheets, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/buried-pipes-tritium.html>
- Edwin Lyman explains tritium... http://www.vpr.net/news_detail/86960/
- Cancer spike around nuclear plants... <http://standardspeaker.com/news/study-nuclear-plant-radiation-may-be-to-blame-for-cancer-spike-1.563288>
- Petition to NRC on Longstanding Radioactive Leaks... http://www.ucsusa.org/nuclear_power/nuclear_power_risk/safety/petition-for-longstanding.html
- Pilgrim Watch Presents Statements Of Position, Direct Testimony And Exhibits Under 10 CFR 2.1207, March 3, 2008. NRC Website, [http://www.nrc.gov/reading-rm/adams.html#web-based-Click “web based Adms Search”](http://www.nrc.gov/reading-rm/adams.html#web-based-Click%20web%20based%20Adms%20Search) - Advanced Search, Accession Number ML080740410

Entergy's Environmental Monitoring

The NRC requires licensees to issue an Annual Environmental Monitoring Program Report. The reports are available each year on NRC's Electronic Library, ADAMS⁹⁹. <http://www.nrc.gov/reading-rm.html>. Pilgrim's docket number for future reference is 05000293.

In response to the proliferation of leaks at reactors around the country, NRC established a task force. Its report is worth reading. Groundwater Contamination (Tritium) at Nuclear Plants-Task Force – Final Report, NRC, Sept 1, 2006.¹⁰⁰

Problem: The Licensees are required to do environmental monitoring offsite and report the results annually. However the environmental monitoring at Pilgrim is inadequate because: the number of samples taken for testing has markedly been reduced over the years; the location of some of the sampling stations is inadequate because the *indicator sampling locations are too close to the reactor*; and Entergy sends the samples to their own lab (Fitzpatrick Lab) for testing and analysis. MDPH's offsite sampling has been reduced due to budgetary concerns and now they are only taking samples provided by Entergy.

Solution: Increase the number of samples; place the indicator sampling locations in areas that are expected to show influence from the reactor; provide split samples to the Mass Department of Public Health for analysis to supplement MDPH's own samples; and assure licensee provides funding for the state program and that the results are regularly reported to the public.

Analysis of Samples, Self analysis: Beginning in July 2002, Pilgrim began using Entergy's J.A. Fitzpatrick Environmental Laboratory for analysis of environmental samples.

⁹⁹ For example, to search for the 2011 report in Advanced search click in property, highlight accession number; click in operator, highlight “is equal to”; click in value, add accession number “ML11143A032.”

¹⁰⁰ Groundwater Contamination (Tritium) at Nuclear Plants-Task Force – Final Report, NRC, Sept 1, 2006 <http://pbadupws.nrc.gov/docs/ML0626/ML062650312.pdf>

If radioactivity is discovered that could be attributed to Pilgrim, the response is denial and/or changing the rules.



Example: Plutonium in sediment sampled at Duxbury Beach

Plutonium found in Duxbury Bay sediment samples dismissed by Entergy – attributed to either weapons testing, cross-contamination from the lab's glassware or simply that the sample was lost.

In 2001, citizens brought to the NRC's attention the level of plutonium reported for Duxbury's sample and complained that the sample station, in reality, was an indicator station due to its proximity and wind direction-not as characterized by Entergy as a control station.

Radiological Environmental Monitoring Program (REMP) Report 1998 2.17 #31:Sediment Radioactivity Analyses

Plutonium 239/240 levels in the indicator samples ranged from 2.2 to 7.9 Pi/kg. The concentration of PU 239/240 in the single sample collected in the control locations beyond the influence of Pilgrim Station was 12.4 Pi/kg. The fact that the results from the indicator locations are lower than those from the control stations indicates that the source of this activity is not Pilgrim Station. The levels detected are also comparable to concentrations observed in the past few years and are indicative of plutonium deposited in the environment from nuclear weapons testing. Emphasis added, Page 33

Radiological Environmental Monitoring Program Report for 1999, 2.17 Sediment Radioactivity Analyses

No plutonium-239/240 was detected in the four indicator station samples but was detected in both of the control station samples. The concentration of Pu-239/240 in the samples collected

from the control locations beyond the influence of Pilgrim Station ranged from 21 to 23 pCi/kg. The levels detected are comparable to concentrations observed in the past few years and are indicative of plutonium deposited in the environment from nuclear weapons testing.

Radiological Environmental Monitoring Program Report for 2000

Plutonium-238 was detected in 2 of 4 indicator samples, and both control samples. Plutonium-239/240 was also detected in two of four indicator station samples, and both control station samples.

Radiological Environmental Monitoring Program Report for 2001 Page 32 2.17 Sediment Radioactivity Analyses

As part of the comparison of sediment analyses results to previous years, questions were raised about the abnormally high plutonium-238 concentrations observed in samples collected during 2000. Follow-up investigations conducted by the analytical laboratory that performed the 2000 analyses concluded that the results were invalid due to cross-contamination from laboratory glassware. This laboratory also analyzes samples for Department of Energy clean-up projects. Due to the expense of the specialized glassware, it is re-used. Updated tables from the 2000

Radiological Environmental Monitoring Program Report for 2002.

2.17 Sediment Radioactivity Analyses

Plutonium analyses are also performed on a mid-depth section from the discharge canal sample and Duxbury sample. Two sets of samples of sediment collected during the first half of the year were not analyzed as required. Although records indicate that the samples were collected and delivered to the analytical laboratory in June, analyses were not performed, and the samples could not be located. Eight depth-incremental sub-samples from Plymouth Harbor, as well as the eight depth-incremental sub-samples from Duxbury Bay were delivered to the lab on 27-Jun-2002 along with 38 samples from the other sampling locations. It is surmised that the samples were assumed to be backup samples from the other locations, not requiring analysis. Two of the samples from the control location in Duxbury were to be analyzed for plutonium, to establish a baseline for comparison to the indicator locations closer to the plant. Plutonium analyses from indicator locations (Discharge Canal Outfall and Manomet Point) indicated no detectable plutonium.

Mass Department of Public Health's Environmental Monitoring

The Radiation Control Program has the statutory authority to conduct environmental monitoring in areas around operating nuclear power stations in or near the Commonwealth. Environmental radiation monitoring devices are deployed at a variety of sites around these power stations, and staff conduct periodic sampling of crops, finfish, shellfish and dairy products originating in these areas. These environmental samples and monitoring devices are evaluated at the Massachusetts Environmental Radiation Laboratory to determine the extent of radioactive releases, if any, from these power stations

The program is underfunded so that the sampling currently is inadequate, Legislation needs to be passed to increase assessment in the MA General Laws, section 5K chapter 111.

MDPH's Environmental Monitoring Reports are available online.

Pilgrim, Vermont Yankee, and Seabrook Nuclear Power Station Emergency Planning Zones

[2015 Report](#)  file size 1MB 

[2014 Report](#)  file size 1MB 

[2012/2013 Report](#)  file size 2MB 

[2011 Report](#)  

MDPH Environmental Monitoring Presentations

[November 19, 2015 Updates on Environmental Radiation Monitoring Activities at Pilgrim Nuclear Power Station \(PowerPoint presentation\)](#)  file size 4MB 

[April 9, 2014 Updates on Environmental Radiation Monitoring Activities at Pilgrim Nuclear Power Station \(PNPS\)](#)  file size 1MB 

November 19, 2015, Updates on Environmental Radiation Monitoring Activities at Pilgrim Nuclear Power Station

III. Routine Environmental Monitoring in Emergency Planning Zones



■ Routine Monitoring - PNPS

- Conducted as part of MDPH regulatory requirements
- Samples collected both within and outside 10-mile Emergency Planning Zone (EPZ)
- Analysis by Massachusetts Environmental Radiation Laboratory (MERL)
- Sampling includes air, surface water, sediment, milk, shellfish, lobster, fish, Irish moss, crops (e.g. cranberries)

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Routine Environmental Monitoring in Emergency Planning Zones

Media	Frequency	Location in EPZ	Location Outside EPZ	Collected By	Analyzed By
Air Filter / Cartridge	Weekly	PNPS	Boston	MDPH	MDPH/MERL
TLDs	Quarterly	EPZ Communities	Boston	MDPH	MDPH/MERL
Real-time Air	Real-time	Plymouth, Duxbury	None	MDPH	MDPH/MERL
Surface Water	Monthly Composite	Discharge Canal, Powder Point Bridge, Duxbury (as background)	None	Entergy	MDPH/MERL
Fish	Twice per Year	Discharge Canal	Cape Cod Bay	Entergy	MDPH/MERL
Lobster	Once per Year	Discharge Canal	Cape Cod Bay	Entergy	MDPH/MERL
Mussels	Twice per Year	Discharge Canal, Plymouth Harbor, Duxbury Bay (as background)	Green Harbor, Marshfield	Entergy	MDPH/MERL
Sediment	Twice per Year	Discharge Canal	Green Harbor, Marshfield	Entergy	MDPH/MERL
Irish Moss	Twice per Year	Discharge Canal	Brant Rock, Marshfield	Entergy	MDPH/MERL
Crops	Once per Year	Plymouth	Bridgewater, Kingston, East Taunton	Entergy, MDPH	MDPH/MERL
Milk	Monthly	None	O'Neil Farm (as indicator)	MDPH	MDPH/MERL

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Routine Environmental Monitoring in Emergency Planning Zones

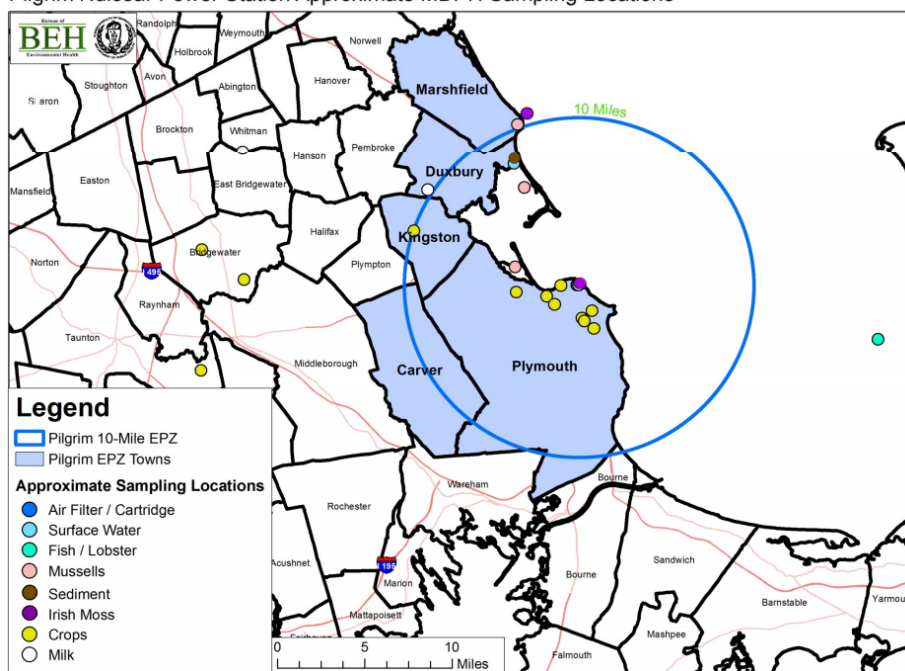
Media	Frequency	Location in EPZ	Location Outside EPZ	Collected By	Analyzed By
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Real-time Air	Real-time	Plymouth, Duxbury	None	MDPH	MDPH/MERL
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Irish Moss	Twice per Year	Discharge Canal	Brant Rock, Marshfield	Entergy	MDPH/MERL
Crops	Once per Year	Plymouth	Bridgewater, Kingston, East Taunton	Entergy, MDPH	MDPH/MERL
Milk	Monthly	None	O'Neil Farm (as indicator)	MDPH	MDPH/MERL

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The majority of the samples are collected by Entergy, not the state. Both the number and type of media sampled is too small. Mussels and surface water are collected in Duxbury Bay are considered a

background sample despite the fact that Duxbury is in the 10-mile EPZ and the reactor is visible from the sampling location.

Pilgrim Nuclear Power Station Approximate MDPH Sampling Locations



Environment: Marine Impact

Once Through Cooling: Pilgrim, like all nuclear reactors, generates too much heat. To remove excess heat, they draw in over 500 million gallons of water a day from Cape Cod Bay. Its license requires that the water temperature drawn in does not exceed 75 degrees. If the temperature exceeds its cap, Pilgrim must shut down losing about \$1.1 million in gross revenue per day and about \$569,000 after all the bills are paid - based on figures from ISO-New England and data from SNL Energy, a data and analysis resource for the utility industry.

Since Pilgrim began operations in 1972, Temperatures exceeded the limit in 2013, 2015 and 2016. In August 2018, Pilgrim had to reduce power as the temperature limit neared the cap, due to Northeasterly winds pushing warm water released from Pilgrim Nuclear Power Station's reactor beyond a breakwater and into a sheltered area where 500 million gallons are drawn each day to cool operational systems. The ocean is being impacted by global warming, and the Gulf Stream current is warming and coming closer to our shore.

Impact Marine Life: Along with the water, they suck in fish eggs and other microscopic organisms; larger fish get pulled in by the current too and become trapped on intake screens. The marine life that is drawn in gets pulverized by the reactor condenser system and emerges as sediment that clouds the water around the discharge area, often blocking light from the ocean floor. The sediment cloud results in killing plant and animal life by curtailing the light and oxygen needed to survive.

The water that is drawn in cycles through and is then released at temperatures 30 degrees above Bay temperature (62F to 100F) – disrupting the ecosystem. The water discharge temperature is averaged over an hour time. The U.S. Environmental Protection Agency wanted Entergy to measure the water temperature discharged instantaneously recognizing that some discharges are 130 degrees or more - although the hourly average remains within limits. Entergy prefers the hourly average. Agreement has not been reached. Some organisms are attracted to the warmer environment. But when the reactor is abruptly shut down, water temperatures will drop causing cold-stunning, fatal to fish acclimated to warmer waters.

The following report *Entergy, Our Bay is Not Your Dump: A Call to EPA and MassDEP to Terminate Entergy's Clean Water Act Permit for Pilgrim Nuclear and end the Destruction and Pollution of Cape Cod Bay*, released June 2015.¹⁰¹ The report documents how Entergy Corporation, owner of the Pilgrim Nuclear Power Station in Plymouth, destroys marine life and pollutes Cape Cod Bay by using an outdated “once-through” cooling water system to run Pilgrim and discharges pollutants into the Bay.

Pilgrim has used the equivalent of the entire volume of Cape Cod Bay over the last four decades for cooling, drawing in and killing about a million fish and billions of plankton, fish eggs, larvae, and other marine life. This is a far greater impact than was projected in pre-permitting studies in 1970 that led to the licensing of Pilgrim in the first place.

In 2006, Entergy sued MassDEP to avoid new water pollution regulations. In 2011, the Supreme Judicial Court upheld the new regulations, saying, “The environmental impact of [CWIS] is staggering... destabilizing wildlife populations in the surrounding ecosystem. In areas with a designated use as aquatic habitat (such as Cape Cod Bay where Pilgrim’s CWIS operates), therefore, CWISs hinder the attainment of water quality standards.”

A report by Stratus Consulting 2002 evaluating habitat replacement costs for EPA’s Region I placed the “kill rate” for fish higher. It said that an average of 14.5 million fin fish and 160 billion blue mussels are estimated to be killed on average each year (based on data from 1973-1999) via entertainment and impingement combined. This would mean that more than a million fish have been killed over the past 4 decades.

Violations by Entergy¹⁰²

- No state CWIS permit as required by 2006 regulations. But **Pilgrim’s new draft permit¹⁰³ arrived May 18, 2016, after 20 years, although they are supposed to be reissued every 5 years to protect Cape Cod Bay.**
- Discharge violations: Since at least 1995, discharging toxic corrosion inhibitors without a state or federal permit; chlorine discharge limit violations in 5 of last 12 quarters.
- The joint EPA-DEP Clean Water Act “NPDES” permit expired 16 years ago; and although it has been “administratively extended” for 16 years, Entergy has violated its terms since 2000.

¹⁰¹Entergy, *Our Bay is Not Your Dump: A Call to EPA and MassDEP to Terminate Entergy’s Clean Water Act Permit for Pilgrim Nuclear and end the Destruction and Pollution of Cape Cod Bay*, 2015 www.capecodbaywatch.org/2015-water-pollution-report/

¹⁰² See NRC Electronic Library, Electronic Hearing Docket <http://adams.nrc.gov/ehd/> Petitioner’s Pleadings in: Pilgrim_CWA; Pilgrim _ ESA-MSA; Pilgrim_ESA-Rosette Tern

¹⁰³ <https://www.epa.gov/sites/production/files/2016-05/documents/draftma0003557permit.pdf>

- The Massachusetts “Section 401 certification” of the NPDES permit is outdated and invalid given unpermitted discharges of various pollutants and other violations.
- Since about 2000, no approved “marine monitoring plan” as required by NPDES permit
- Since 2000, Entergy has refused to cooperate with the required technical advisory committee, which was set up as an “integral part” of the NPDES permit. Entergy is not meeting its obligations: without compliance with this critical provision, the permit is meaningless.
- Radioactive tritium is leaking into the groundwater which flows into Cape Cod Bay.
- State 2006 coastal zone management “federal consistency certification” is invalid.

Pilgrim Nuclear Power Station: Review of intake and discharge effects on finfish

The report is not as current as we would like, but its insights are relevant.

Technical Memorandum For The Record

By: Gerald M. Szal (DEP), August 30, 2005

Subject: Pilgrim Nuclear Power Station: review of intake and discharge effects to finfish

Potential impacts to aquatic life from the operation of the Pilgrim Nuclear Power Station are divided into two categories: those from the intake of cooling water, and those from the discharge of heated effluent. Intake effects are further divided into two categories: those from impingement on intake screens at the entry of the intake bay; and those from entrainment of fish eggs and larvae through the facility. Discharge effects discussed include those from the cooling water discharge and those from the heated backwash used to control biofouling in the intake bays.

Intake Effects

Impingement

Effects to winter flounder: Impingement effects to this species are typically small at the Pilgrim facility. An estimated total of slightly over 2,000 winter flounder were impinged in year 2004. Most, if not all, of these were young of the year. This is the second highest impingement rate in the past 25 years of monitoring, but does not appear to represent a significant impact to the population.

Effects to other finfish species: The following fish species were considered those suffering the greatest numerical losses due to impingement over the last 11 years of monitoring at Pilgrim (Environmental Protection Group 2005):

Table 1

Year	A t l a n t i c silverside	Atlantic menhaden	b l u e b a c k herring	grubby	r a i n b o w smelt	alewife
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1994	36,498	58	269	1,094	9,464	123
1995	13,085	1,560	1,244	648	2,191	39,884
1996	16,615	2,168	2,462	1,347	3,728	216
1997	6,303	1,329	424	405	1,978	317
1998	6,773	1,423	134	335	1,656	158
1999	8,577	42,686	550	628	875	610
2000	25,665	34,354	5,919	1,105	13	2,443
2001	4,987	3,599	229	517	879	1,618
2002	4,430	53,304	943	1,087	335	334
2003	23,149	119,041	1,968	237	532	438
2004	13,107	10,431	2,046	2,257	1,092	145

Of particular interest are the rainbow smelt. These fish are an anadromous species and smelt impinged at Pilgrim most probably come from the Jones River population. Although there are two other rainbow smelt runs (Town Brook and Eel River) in the Plymouth/Kinston/Duxbury Bay area they are apparently quite small in comparison to that from the Jones River (based on pers. comm., Brad Chase, MA Division of Marine Fisheries [DMF] to Gerald Szal, DEP). Rainbow smelt are not known to reproduce elsewhere in streams entering Cape Cod Bay or in streams elsewhere on Cape Cod.

During the late 1970s, there were a number of rainbow smelt impingement events at the Pilgrim facility. In 1978 an estimated 6,200 rainbow smelt died during a three-week period in December from impingement episodes at the facility. At the time, a group of state, federal, university and facility personnel met regularly to address potential impacts from the facility. Concern was expressed by these biologists that impingement events from Pilgrim could be significantly affecting the Jones River smelt population. This prompted DMF to conduct an intensive, three-year (1978-1981) study (see Lawton, et al., 1990) to develop an estimate of the adult rainbow smelt population size in the Jones River so that an assessment of the plant's effects could be evaluated.

Results of the Lawton, et al., study state that, based on an estimate of egg production, an unbiased sex ratio, and age-specific fecundity, rainbow smelt spawning stock abundance was estimated to be 4,180,000 adults in 1981. The 6,200-fish loss due to impingement was projected to have reduced the Jones River spawning population by less than one percent, and was not considered to have a significant, negative effect on that population.

Based on a recent interview with personnel at the Division of Marine Fisheries, there have been no recent quantitative estimates of the adult rainbow smelt population in the Jones River. However, judging from visual information on both egg density and adult movement, Brad Chase, DMF (pers. comm. to G. Szal, August 29, 2005) estimates that there has been a sharp decline in the rainbow smelt population in the Jones River since the time when the Lawton, et al. (1990), studies were conducted. Unfortunately, without a quantitative evaluation of the rainbow smelt population size in the Jones river, Mr. Chase felt it was not possible to assess the potential impact of Pilgrim's impingement events on the Jones River smelt population.

Entrainment

Effects to winter flounder: Entrained organisms at power plants are typically subjected to a number of stresses including mechanical stress, stress from pressure drop and stress from rapid heating (delta temperature effects). Winter flounder are the primary species of concern at many facilities along coastal Massachusetts due to their intrinsic economic value and recent population decreases. The Pilgrim Nuclear facility employs several methods of evaluating the impact of the intake on the local winter flounder population adjacent to the facility. The first is the “equivalent adult” method in which the estimated number of eggs and larvae entrained (and assumed killed) by the facility are theoretically “grown up” into adults of different age categories based on literature reports on percent survival from one life stage to the next in wild populations. The number of equivalent adults of a particular adult age (e.g., 3-year olds) can be compared with the number of actual adults, of many year classes, found per square mile in areas adjacent to the facility to form an index of impact.

Density of adult winter flounder was assessed primarily in Plymouth/Kingston/Duxbury Bay (PKDB) and adjacent waters, as these areas were thought to be the primary spawning ground that produced the larvae and eggs entrained by the facility. Researchers conducted sampling in this area using a commercial “otter trawl”, a device used to capture bottom fish. The number of equivalent adults cropped by the facility divided by the mean number of flounder found per square mile of PKDB and adjacent areas was used to provide a rough idea of the effect of the facility’s impacts due to entrainment of winter flounder.

There are a number of difficulties to be overcome if one is to use this approach. First there are issues encountered in sampling both the adult population in the field as well as the egg and larval population entrained. For example, researchers conducting this work have assumed an otter trawl efficiency of 50%, but the actual efficiency may be much lower (or higher), which would alter the number of fish in the study area per square mile and the apparent impact. Second, entrainment sampling results, in addition, are quite variable. Third, it is difficult to determine the accuracy, and therefore, the applicability, of the survival matrix used in estimating equivalent adults.

Three age-specific survival matrices were provided by Entergy Nuclear (Environmental Protection Group 2005). One matrix uses un-staged larval information (i.e., all larvae are considered to be the same age); the other two use survival data from one stage to the next for four different larval life stages. Because staged larval survival data should provide a greater degree of accuracy, un-staged information was not used for this review. Of the two remaining matrices, that provided by Gibson (1993) was chosen to evaluate winter flounder issues in Mt. Hope Bay as it was also used in analyses conducted for the Brayton Point facility in Mt. Hope Bay.

A fourth difficulty in estimating impact is choosing a particular adult age class for equivalent adults entrained. The author assumed (see below) that the number of Age-4 equivalent adults entrained is proper for comparison to the estimate of the number of adults per square mile, all ages, found in the study area. Many winter flounder are fully mature at Age-3, but some are not (pers. comm. Robert Lawton, MADMF to Gerald Szal, MADEP). Age-4 was used because almost all winter flounder in the Cape-Cod Bay area are mature at Age-4 (pers. comm. R. Lawton to G. Szal). A more accurate estimate of impact could be prepared if a matrix of length-age-survival data were available for the field population.

The following table provides estimates of entrainment impacts at the Pilgrim Nuclear Power Plant facility in Plymouth, MA, on the local winter flounder population. Estimates are based on data from the Environmental Protection Group (2005).

Table 2

Year	No. Adult Winter Flounder in study area ¹	No. Adult Winter Flounder per square mile ²	E s t i m a t e age-3 adults entrained ³	E s t i m a t e age-4 adults entrained ⁴	Square miles age-4 adults lost to entrainment ⁵
1995	212,989	2,063	9,703	5,919	2.9
1996	316,986	3,070	15,401	50,851	3.1
1997	313,959	3,041	47,091	28,726	9.4
1998	264,812	2,565	77,394	47,210	18.4
1999	176,271	1,707	2,383	1,454	0.9
2000	464,176	4,496	4,521	2,758	0.6
2001	400,812	3,882	33,626	20,512	5.3
2002	476,263	4,613	19,703	12,019	2.6
2003	262,604	2,544	2,951	1,800	0.7
2004	157,532	1,526	50,851	31,019	20.3

Footnotes:

1. Adults were those fish that were ≥ 280 mm in total length.
2. The size of the study area changed over the course of the evaluations. According to J. Scheffer (Pilgrim) all estimates in this column are corrected to the same study area size. They have been based on the area swept by the otter trawl used to capture winter flounder and a trawl efficiency of 50%. The current (2004) size of the study area is about 103 square miles.
3. The equivalent adult method of estimating how many adults of age 3-years would have resulted from the eggs and larvae entrained by the facility, based on literature growth and survival data, was used to obtain these figures. Age-3 adult data were taken directly from Pilgrim Report No. 65; literature data used to calculate survival from one stage to the next was that from Gibson, 1993, as reported by Entergy Nuclear (2005).
4. Age-4 adult numbers were estimated based on a survival of 0.67 (pers. comm., Robert Lawton, MADMF to Gerald Szal, MADEP) from Age-3 to Age-4.
5. Calculated as: (Age-4 adults entrained)/(No. winter flounder per square mile). Because the study area is about 100 square miles (actually 103), these figures are approximately equivalent to the percentage loss to the population in the study area.

Entrainment loss as square miles of adult flounder, using Age-4 equivalent adults entrained, ranged from 0.6 to 20.3 square miles over the 10 years of evaluations. That is, entrainment effects from the Pilgrim facility were estimated to be equivalent to a loss of all adult flounder in an area ranging from 0.6 to 20 square miles in the area adjacent to the facility, given the assumptions outlined above. Because the study area was approximately 100 square miles in size, the square mile losses in this last column approximate a percentile loss to the population at large, although, again, the caveats mentioned above should be kept in mind when viewing these estimates. Whether or not these levels of impact are a “significant” detriment to the population and will result in slowing the return to much higher population densities, is currently unknown and a policy statement regarding losses on a square mile basis has not been issued by any of the state or federal agencies. EPA Region 1 has stated in the past that population impacts of 5% or greater are typically of concern. However, to the author’s knowledge, the geographic bounds of this particular population have not been agreed upon by state or federal agencies.

A second method of estimating entrainment impact to winter flounder used by the facility was to estimate the percentage of the total larval population passing in front of the facility that is entrained. Estimates of percent entrainment were very low, i.e., less than 1%.

The third method used by the facility to evaluate impact was the RAMAS (Risk Analysis Management Alternative System; Ferson, 1993) winter flounder model. It was used from 1999-2001 to further evaluate the effects of the facility on the Cape Cod Bay winter flounder population. Results suggested that stock reductions from 2.3 to 5.2% might occur as the direct result of entrainment at the facility.

Effects to other finfish species

Several species, besides winter flounder, suffer substantial entrainment losses at the Pilgrim facility. These are cunner, mackerel, menhaden and atlantic herring. Numbers of equivalent adults (of different ages) estimated by the facility to have been lost due to entrainment effects on eggs and larvae are listed below:

Table 3: Estimates of the equivalent numbers of adult fish (at age in years in parentheses) entrained by Pilgrim from 1994-2004. Estimates are based on data in Environmental Protection Group (2005); (note: Atlantic herring figures are for entrainment/impingement combined and could not be separated due to the manner in which they were reported).

Year	Cunner (1)	Mackerel (3)	Menhaden (2)	Atlantic herring (3)
1994	174,726	830	732	10,774
1995	525,573	6,245	2,452	25, 518
1996	313,002	3,526	1,781	6,096
1997	465,986	942	10,531	16,091
1998	1,542,473	1,824	7,564	2,697
1999	332,601	60	4,072	7,518
2000	319,247	1,216	178	8,120
2001	473,361	311	349	2,701
2002	101,668	482	1,382	2,425
2003	82,467	514	1,187	699
2004	188,107	304	50	3,169

Screenwash and Fish-Return System

Intake screen wash: The cooling water intake bay at Pilgrim has a number of fine-mesh screens within it that are used to keep fish (but not most fish larvae and eggs) from being brought into the facility. Fish impinged upon these screens can suffer negative acute or chronic effects. At Pilgrim, impinged fish are

knocked off the screens by a salt-water spray system. Under normal operation, screens are rotated only once per 8-hour shift. At the end of the shift, the screens are rotated, and the spray system is operated to dislodge fish from the screens. These fish are shunted to a holding tank where they are counted and further shunted to the intake embayment about 100yds upstream of the intake. If the number of fish during one of these 8-hour periods exceeds 160 fish (rate of 20 fish/hour) an “impingement event” is declared. During such an event, the screens are put into constant rotation, and the event is monitored (i.e., fish are counted) until the event is over. The event is reported as soon as possible after it begins and information on species involved, life stages and numbers of fish is related to the permitting authorities and the Massachusetts Division of Marine Fisheries.

Impinged fish are released into the intake embayment, about 100 yards upstream of the intake bay. To the author’s knowledge no studies have been done to evaluate re-impingement rates. Although large-scale impingement events (>100,000 fish) have taken place at the facility, most of these have been with young-of-the year.

The pressure-wash spray system has two sets of nozzles. The first to come in contact with impinged fish is a low-pressure wash (20 pounds per square inch [psi] or less) which is used to remove most fish from the intake screens. The second is a high-pressure wash (80-100 psi) which removes any remaining fish and/or debris. Water for the spray wash is drawn from the saltwater service system and is de-chlorinated prior to use. Reasons for chlorinating this system are explained below.

There are five salt service water pumps at Pilgrim, each with a capacity of 2,500 gallons per minute. The salt service water system has two purposes. It is used to supply cooling water to a number of components within the plant but is also used for emergency cooling. Typically, four pumps are kept running and the other is kept in reserve. Because the saltwater service system must constantly be available for emergency cooling, chlorine alone is used to prevent biofouling within the system. Thermal backwashing (see below), a method used to control biofouling in the intake bays, is not allowed by the Federal Nuclear Regulatory Commission within this system because the water in the saltwater service system must constantly be kept cool. The target concentration for chlorine within this system is 0.25 mg/L but the system concentration may reach 1.0 mg/L. Water for this system is taken from the intake bay; chlorinated water from this system is released through the 010 discharge into the primary discharge canal (discharge number 001). Because the 001 discharge is so large (310,000 gpm), the chlorine concentration (after mixing) in the discharge canal due to the 010 release should not reach levels that are above water quality standards.

Discharge Effects

Cooling water discharge: The Pilgrim Nuclear facility’s discharge is located in an open-coastal environment and is well situated for rapid mixing of its heated discharge. Effects of the heated discharge on finfish, benthos and Irish Moss were studied for more than twenty years. Primary impacts include at least two well-documented events of gas-bubble disease in finfish in the 1970s. Since that time, to the author’s knowledge, no other major events appear to have taken place. In addition, due to effects on Irish Moss, the facility reimbursed one harvester for losses. Effects of the discharge on the benthic community appear to be primarily limited to scouring. Judging from diver-assisted studies conducted in the late 1990s, it appears that no more than 1-2 acres of the benthic community were negatively affected by the plant’s discharge.

Thermal backwash: About four to five times a year, for a period of about 1.5 to 2 hours, heated water from the downstream end of the steam condensers is re-routed back through the system and out through the intake embayment. This is done to control macro-fouling, primarily from mussels. To accomplish this, the facility shuts down one of the two intake pumps and pushes hot water back through half the system. During this period (about 34-45 minutes) the water within the half of the system receiving the backwash is typically heated to between 105°F and 110°F, but may reach as high as 120°F. The second half of the system is treated in the same manner. Because the facility has to reduce load during these times, which is expensive, the duration and number of backwashes per year is kept to a minimum.

In summary, during a thermal backwash, about 155,000 gpm of heated water (>105°F) is sent into the intake embayment for a period of about 1.5-2 hrs. Studies to evaluate potential impacts of the thermal backwash have not been performed to the knowledge of the author.

Recommendations to minimize impacts from Pilgrim.

1. Resource agencies, in concert with the permitting agencies, should consider further evaluation of the intake effects to winter flounder. If effects are found to be substantial, these agencies should determine what steps need to be taken to reduce the impacts of the facility on the winter flounder population.
2. Because impinged fish from the intake screens are shunted back into the intake, there is a concern that these fish, weakened from impingement, will simply be re-impinged. Permitting and resource agencies should consider requesting an assessment of re-impingement rates to select species of concern. These studies should also assess the need to re-locate the discharge point for impinged fish in order to minimize re-impingement.

Literature Cited

- Gibson, M.R. 1993. Population dynamics of winter flounder in Mt. Hope Bay in relation to operations at the Brayton Point electric plant. Rhode Island Division Fish and Wildlife, West Kingston, R.I.
- Environmental Protection Group. 2005. Marine Ecology Studies, Pilgrim Nuclear Power Station. Report No. 65, Report Period: January 2004-December 2004, Date of Issue: April 30, 2005. Entergy Nuclear – Pilgrim Station, Plymouth, MA.
- Ferson, S. 1993. RAMAS/stage. Generalized Stage-based Modeling for Population Dynamics. Applied Biomathematics, Setauket, New York. 107 p.
- Lawton, R., P. Brady, C. Sheehan, S. Correia and M. Borgatti. 1990. Final report on spawning sea-run rainbow smelt (*Osmertus mordax*) in the Jones River and impact assessment of Pilgrim Station on the population, 1979-1981. Dept. Fisheries, Wildlife and Environ. Law Enforcement, MA Division of Marine Fisheries, 18 route 6A, Sandwich, MA 02563.

RESOURCES MARINE IMPACT

Cape Cod Bay Watch <http://www.capecodbaywatch.org/>
Jones River Watershed Association <http://jonesriver.org/jrwa/>
Licensed to Kill: Classic report explaining once-through cooling
<http://www.nirs.org/reactorwatch/licensedtokill/licensed2kill.htm>
Riverkeeper in New York challenges to Indian Point's once-through –cooling and protect marine life at
<http://www.riverkeeper.org/?s=once+through+cooling&area=>

RISK ASSESSMENT

Probabilistic Risk Assessment (PRA)

PRA's Incapable of Dealing With Unknowns

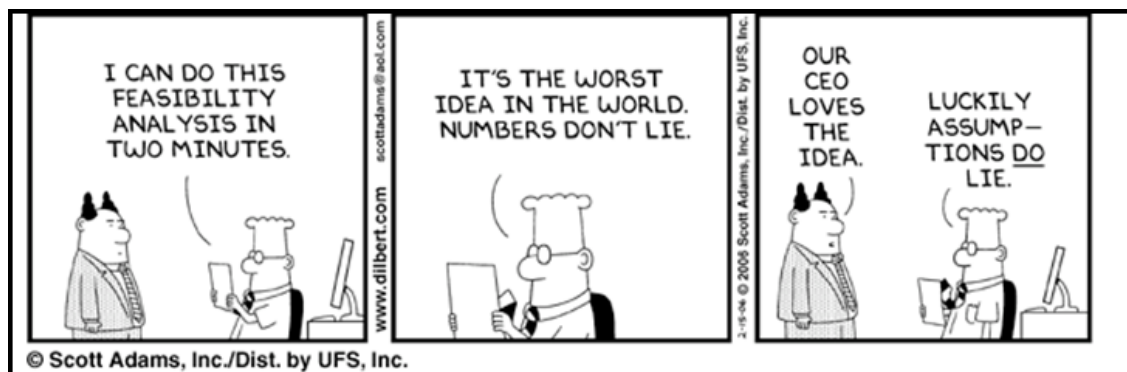
PRA's Outdated

PRA's use incorrect Assumptions

Probabilistic Risk Assessment (PRA)

The NRC uses Probabilistic Risk Assessment (PRA) to estimate risk by computing real numbers to determine what can go wrong, how likely is it, and what are its consequences. A PRA can estimate three levels of risk. Level 1 PRA estimates the frequency of accidents that cause damage to the nuclear reactor core. This is commonly called core damage frequency (CDF). Level 2 PRAs starts with the Level 1 core damage accidents and estimates the frequency of accidents that release radioactivity from the nuclear power plant. Level 3 PRAs starts with the Level 2 radioactivity release accidents, estimates the consequences in terms of injury to the public and damage to the environment.

The numbers in NRC's or industry's PRAs may add up correctly but the answer will be wrong when the assumptions underlying the PRAs are incorrect.



PRAs are incapable of dealing with unknowns so that both quantitative and qualitative analyses are required, along with defense in depth measures. NRC and industry are eager to stick simply with quantitative analyses.

PRAs are rooted in a *pre-Fukushima* way of thinking and assumptions so that there is little chance that any prioritizing of safety issues resulting from their use will be reliable. Even before Fukushima it was apparent that the computational tools used for PRAs are outdated and unreliable – the Melcor Accident Consequence Code (MACCS2¹⁰⁴) and SOARCA.¹⁰⁵ MACCS2 is used to assess offsite economic consequences; and SOARCA is NRC's code to estimate offsite radiological health consequences for

¹⁰⁴ Melcor Accident Consequence Code, MACCS2, is the computer code generally accepted and used in the nuclear industry to calculate costs of a severe accident. It was released in 1997, developed as an improved version of MACCS, which replaced the earlier CRAC code. The MACCS2 evaluates major factors of a severe accident that contribute to offsite costs- release characteristics, weather pattern, population profile, some cleanup costs, some health costs, and other factors that affect cost of severe accident. It has 3 steps- ATMOS (calculates and ground concentrations, plume size, and used straight-line Gaussian plume) EARLY (calculates consequences due to exposure in first 7 days, the emergency phase of accident) and CHRONC (calculates long-term effects and computes decontamination and economic impacts).

¹⁰⁵ <http://www.nrc.gov/about-nrc/regulatory/research/soar.html>

potential severe reactor accidents. Both computational tools minimize consequences to assure meaningful mitigation (costs to industry) will never be justified.

PRAs Incapable of Dealing with Unknowns- Qualitative Analyses Required

NRC Chairman Allison M. Macfarlane in her prepared remarks at the 2013 NRC RIC, March 12, 2013 made the point by saying that, “The famed physicist Niels Bohr quipped, ‘prediction is very difficult, especially about the future.’ I’ve spent a lot of time studying and writing about this subject...it is unwise to think we can confidently predict what lies ahead.”

Prior to that, NRC acknowledged the importance of defense-in-depth and limitations of PRA. Regulatory Guide 1.174, which deals with risk-informed decision making on changes to the licensing basis of plants, provides a good summary. It says that, “Defense-in-Depth...has been and continues to be an effective way to account for uncertainties in equipment and human performance.” Recurrent themes in applications of defense-in-depth do not rely on one element of design no matter how confident, and guard against the unexpected, i.e., does not assume accidents will start and play out in the analyzed way. Fukushima sadly showed this to be true; do we in the U.S. have to learn the hard way?

Also, NUREG 1855 warned that, “In implementing risk-informed decision-making, the U.S. Nuclear Regulatory Commission expects that appropriate consideration of uncertainty will be given in the analyses used to support the decision and in the interpretation of the finding of those analyses.”

Kamiar Jamali’s (DOE Project Manager for Code Manual for MACCS2) *Use of Risk Measures in Design and Licensing Future Reactors*¹⁰⁶ explains that “PRA” uncertainties are so large and so unknowable that it is a huge mistake to use a single number coming from them for any decision regarding adequate protection. “Examples of these uncertainties include probabilistic quantification of single and common-cause hardware or software failures, occurrence of certain physical phenomena, human errors of omission and commission, magnitudes of source terms, radionuclide release and transport, atmospheric dispersion, biological effects of radiation, dose calculations, and many others.” (Jamali, Pg., 935) NRC Commissioners¹⁰⁷ “have not endorsed a ‘risk-based’ approach to regulation because of the uncertainties in quantitative results in PRAs. These uncertainties are large for currently operating plants, particularly in the so-called Level 2 and Level 3 PRAs.”¹⁰⁸

¹⁰⁶ Kamiar Jamali, *Use of Risk Measures in Design and Licensing Future Reactors*, Reliability Engineering and System Safety 95 (2010) 935-943

¹⁰⁷ SECY-98-144 White Paper on Risk Informed and Performance –Based Regulation, January 22, 1998. Staff requirements memorandum approved March 1, 1999; NRC Regulatory Guide 1.174, An approach for using probabilistic risk assessment in risk-informed decisions on plant changes to the licensing basis, Rev. 1, November 2002 (Section 1.4 states “...the NRC has chosen a more restrictive policy that would permit only small increases in risk, and then only when it is reasonably assured, among other things, that sufficient defense in depth and sufficient margins are maintained. This policy is adopted because of uncertainties and to account for the fact that safety issues continue to emerge regarding design, construction, and operational matters notwithstanding the maturity of the nuclear power industry.”

¹⁰⁸ Kamiar Jamali, *Use of Risk Measures in Design and Licensing Future Reactors*, Reliability Engineering and System Safety 95 (2010) ,936

SECY-98-144 White Paper on Risk Informed and Performance-Based Regulation, January 22, 1998. Staff requirements memorandum approved March 1, 1999; NRC Regulatory Guide 1.174, an approach for using probabilistic risk assessment in risk-informed decisions on plant changes to the licensing basis, Rev. 1, November 2002. Section 1.4 says:

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PRA's Outdated & Use Incorrect Assumptions

There is a very long list of lessons that the NRC and the nuclear industry should have learned from Fukushima. The following are among the most important. The NRC's current methodology for estimating the consequences of a severe accident either ignores or drastically underestimates all of them.

1. PRAs Underestimate Probability: The probability of a core damage event is ten times what the NRC has assumed – from 1 event in 31,000 reactor years (RY) to 1 event per 2,900 RY.

Put another way, based upon observed experience with more than 400 reactors operating worldwide, a significant nuclear accident has occurred approximately every seven years ($2900/400=7.25$).¹⁰⁹

Consequence analysis multiplies the probability of an accident by the consequences. By multiplying large consequence values by very low probability, the consequence values appear unrealistically very low – far lower than the real-world lessons from Fukushima show.

Probabilistic modeling that uses a low probability number can, and likely will, underestimate the deaths, injuries, and economic impact likely from a severe accident. No matter how high the potential consequence values may be, if they are multiplied by a low probability number, the consequence figures on which decisions are based become far less startling assuring fixes are not justified.

Kamiar Jamali's *Use of Risk Measures in Design and Licensing Future Reactors*¹¹⁰ showed that that "PRA" uncertainties are so large and so unknowable that it is a huge mistake to use a single number coming from them for any decision regarding adequate protection. Probability analysis has other pitfalls.

PRAs do not consider human error. More important, PRAs project into the future and assume (based on very little real experience) that there is a likelihood that an accident scenario will occur in hundreds, if not thousands, of years is vanishingly small. But no reactors have operated more than 45 years, and

¹⁰⁹ These two quite different ways of stating probability of a Core Damage Event (once every seven years or once in every 2,900 reactor years) is perhaps one of the clearest examples of the ability of a PRA to confuse and mislead the public.

¹¹⁰ Kamiar Jamali, *Use of Risk Measures in Design and Licensing Future Reactors*, Reliability Engineering and System Safety 95 (2010) 935-943

there have been at least six severe accidents.¹¹¹ The uncertainty inherent in predicting the future must be respected by making certain that appropriate and up-to-date assumptions are used in the analysis.

2. PRAs Ignore Spent Fuel Pool Accidents: The NRC's "economic consequence" analyses cannot continue simply to ignore the enormous (far more than a core meltdown) damage that a spent fuel pool accident will cause.

The danger presented by spent fuel at Fukushima is the reason that the NRC recommended that all Americans within 50 miles of Fukushima be evacuated. Yet the NRC's economic consequence analyses (inexplicably for any reason other than the potential cost to the industry of dealing with the issue) continue to ignore the consequences of a spent fuel accident.

At Pilgrim a spent fuel pool fire could release more than 44,010,000 curies of Cs-137, an amount 8 times more than a core release. Further, a spent fuel pool fire would result in releases going higher into the air and significantly impacting locations at greater distance with denser populations. Dr. Beyea estimated the cost of a 10% release from a spent pool fire to be \$105-175 billion dollars; and that a 100% release of C-137 would cost somewhere between \$342 - \$488 billion.¹¹²

A more recent study by Frank von Hippel and Michael Schoeppner of Princeton University found that a **major fire could contaminate as much as 100,000 square kilometers (38,610 square miles) of land and force the evacuation of millions**¹¹³. It would dwarf the accident at Fukushima resulting in trillion-dollar consequences.

3. PRAs Do Not Model Aqueous Discharges

In the event of a severe accident, there will be enormous aqueous radioactive releases and damage. This liquid discharges result from direct contamination from water pumped into a reactor and then leaked outside and transported through subsurface water, sediments, soils and groundwater, plus atmospheric fallout on the waters - resulting in three sources of contamination in the waters. The NRC's approved consequence analyses cannot continue to ignore aqueous releases. Millions of gallons of water were pumped into the Fukushima reactors, and those millions of gallons flowed into the sea. Current NRC economic consequences take no account of aqueous discharges, to say nothing of their affect on either the local or long-distance marine economies. The importance of including aqueous discharges in PRAs

¹¹¹ Including the 1961 fatal accident at SL-1

¹¹² The Massachusetts Attorney General's Request for a Hearing and Petition for Leave to Intervene With respect to Entergy Nuclear Operations Inc.'s Application for Renewal of the Pilgrim Nuclear Power Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Potential Consequences Of A Spent Fuel Pool Fire At The Pilgrim Or Vermont Yankee Nuclear Plant, Jan Beyea, PhD., May 25, 2006.

¹¹³ Richard Stone, "Spent fuel fire on U.S. soil could dwarf impact of Fukushima," *Science*, May 24, 2016. (available at: <http://www.sciencemag.org/news/2016/05/spent-fuel-fire-us-soil-could-dwarf-impact-fukushima>)

was recognized by the Commission.¹¹⁴ But the Commission also should do something about it to assure they are included in modeling. Once included, it will lead to potential fixes becoming justified.

4. PRAs Limit Duration of Accidents To (1-4) days

There is no rational basis for the NRC/industry assumption that an accident will last only a day (usual industry practice) and in any event not more than 4 days (MACCS2 code's maximum limit). The MACCS2 code limits the total duration of a radioactive release to no more than four (4) days, if the user chooses to use four plumes occurring sequentially over a four day period (IPLUME 3)¹¹⁵. Licensees, for example, have chosen not to take that option and limited analyses to a single plume having a total duration of one day.¹¹⁶ In any case either a day or a four-day plume is plainly of insufficient duration in light of lessons learned from Fukushima. Releases that go on for months or years will cause offsite consequences that far exceed one that lasts only a day.

5. PRAs Limit Radioactive Releases to Gamma and Small Fraction Cs-137

There is no rational basis for the NRC/industry assumption that the only radioactive release that needs to be considered is an atmospheric (forget about aqueous) release from the core (forget about the spent fuel pool), and even then only noble gasses and a small fraction of the Cs-137 in a core need be taken into consideration. Limiting releases is designed to minimize consequences and industry's potential mitigation costs.

6. PRAs Limit Radioactive Release Concentration by Use Straight-Line Gaussian Plume Instead of Meteorological Models for Complex Terrains

Similarly, there is no rational basis for the NRC/industry assumption that a radioactive release will only affect a very limited geographic area defined by an outdated straight-line Gaussian plume. The atmospheric dispersion model embedded in the MACCS2 code is a steady-state, straight-line Gaussian plume model that assumes meteorological conditions that are steady in time and uniform spatially across the study region.

The plume model is not appropriate for sites located near large bodies of water, river valleys and varied topography. It underestimates the area likely to be affected in a severe accident and the dose likely to be received in those areas.

Variable plume models such as AERMOD or CALPUFF are appropriate, and readily available. The NRC knows this. For example NRC made a presentation to the National Radiological Emergency Planning

¹¹⁴ SECY-11-0089, Enclosure 1, pg., 29; <http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2011/2011-0089scy.pdf>; and Commission Voting Record, Decision Item SECY-11-0089, September 21, 2011, <http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2011/2011-0089vtr.pdf>

¹¹⁵ NUREG/CR-6613 Code Manual for MACCS2: Volume 1, User's Guide, 2-2

¹¹⁶ The MACCS2 uses a Gaussian plume model with Pasquill-Gifford dispersion parameters (Users code 5-1). Its equation is limited to plumes of 10 hour duration.

Conference¹¹⁷ concluded that the straight-line Gaussian plume models cannot accurately predict dispersion in a complex terrain and are therefore scientifically defective for that purpose [ADAMS - ML091050226, ML091050257, and ML091050269 (page references used here refer to the portion attached, Part 2, ML091050257).]

Most reactors, if not all, are located in complex terrains. In the presentation, NRC said that the “most limiting aspect” of the basic Gaussian Model, is its “inability to evaluate spatial and temporal differences in model inputs” [Slide 28]. Spatial refers to the ability to represent impacts on the plume after releases from the site e.g., plume bending to follow a river valley or sea breeze circulation. Temporal refers to the ability of the model to reflect data changes over time, e.g., change in release rate and meteorology [Slide 4]. Because the basic Gaussian model is non-spatial, it cannot account for the effect of terrain on the trajectory of the plume – that is, the plume is assumed to travel in a straight line regardless of the surrounding terrain. Therefore, it cannot, for example, “‘curve’ a plume around mountains or follow a river valley.” NRC 2009 Presentation, Slide 33.

Further NRC says that it cannot account for transport and diffusion in coastal sites subject to the sea breeze. The NRC says that the sea breeze causes the plume to change direction caused by differences in temperature of the air above the water versus that above the land after sunrise. If the regional wind flow is light, circulation will be established between the two air masses. At night, the land cools faster, and a reverse circulation (weak) may occur [Slide 43]. Turbulence causes the plume to be drawn to ground level [Slide 44]. The presentation goes on to say that “Additional meteorological towers may be necessary to adequately model sea breeze sites” [Slide 40].

Significantly, the NRC 2009 Presentation then discussed the methods of more advanced models that *can* address terrain impact on plume transport, including models in which emissions from a source are released as a series of puffs, each of which can be carried separately by the wind, (NRC 2009 Presentation Slides 35, 36). This modeling method is similar to CALPUFF. Licensees are not required, however, to use these models in order to more accurately predict where the plume will travel to base protective action recommendations.

Likewise, EPA has recognized the need for complex models. For example EPA's November 2005 Modeling Guideline (Appendix A to Appendix W) lists EPA's "preferred models" and the use of straight line Gaussian plume model, called ATMOS, is not listed. Sections 6.1 and 6.2.3 discuss that the Gaussian model is not capable of modeling beyond 50 km (32 miles) and the basis for EPA to recommend CALPUFF, a non - straight line model.¹¹⁸ DOE, too, recognizes the limitations of the straight-line Gaussian plume model. They say for example that Gaussian models are inherently flat-earth models, and perform best over regions of transport where there is minimal variation in terrain. Because of this, there is inherent conservatism (and simplicity) if the environs have a significant nearby buildings, tall vegetation, or grade variations not taken into account in the dispersion parameterization.¹¹⁹

7. PRAs Underestimate Cleanup/Decontamination

¹¹⁷ What's in the Black Box, Dispersion, Prepared for 2009 National Radiological Emergency Planning Conference, Stephen F. LaVie, Sr. Emergency Preparedness Specialist, Nuclear Security and Incident Response, Division of Preparedness and Response, Adams Accession No. ML091050257

¹¹⁸ http://www.epa.gov/scram001/guidance/guide/appw_05.pdf

¹¹⁹ The MACCS2 Guidance Report June 2004 Final Report, page 3-8:3.2 Phenomenological Regimes of Applicability

Clean-up and decontamination is an enormously expensive job, extending over decades. They are the “Elephant in the Room.” Hosing down buildings and plowing under fields does not clean-up or decontaminate. The NRC cannot continue to ignore that there is no cleanup-standard; that clean-up cannot possibly take just one year; that it has given no consideration to what can and must be done to the tons of contaminated wastes; that clean-up after a nuclear explosion is not comparable to clean-up after a nuclear reactor accident; and that forests, wetlands and water simply cannot be cleaned and will re-contaminate areas. The cost formula used in the MACCS2 underestimates costs likely to be incurred.

The current NRC approved consequences models:

- Underestimate both the size of the area likely to be contaminated, and the extent of contamination. Size of area contaminated minimized by assuming a straight-line Gaussian plume model; extent of contamination minimized by, ignoring aqueous discharges, and ignoring that an accident can persist over many weeks and months.
- Underestimate the volume of waste; and that there are no available safe disposal options is ignored. In fact, waste disposal is not modeled.
- Underestimate the time that decontamination will take. Technologies to cleanup have not been developed; current cleanup methods used in Japan and assumed in US models do not work- hosing down buildings and plowing under fields. They are based on nuclear weapons cleanup that is a different from cleanup after a nuclear reactor accident¹²⁰. Many radionuclides, like Cs-137, have long half-lives.
- Ignore that the technologies needed for cleanup have not even been developed.
- Ignore that forests, wetlands, and bodies of water essentially cannot be cleaned up or decontaminated.
- Ignore there is not even a cleanup standard.

The New York Times reported April 14, 2015, that,

A **Fukui Prefecture court** in Japan has ruled that the only real protection from a catastrophic nuclear accident is to keep the nation’s atomic reactors shut down. Hideaki Higuchi, a local judge for Fukui, **ordered that the Takahama nuclear power plant remain closed** as there is not adequate proof that another disaster caused by an earthquake can be reliably averted if

¹²⁰ The MACCS2 cleanup assumptions used by NRC and industry are directly based on WASH-1400; WASH-1400, in turn, was based on clean up after a nuclear explosion. Cleanup after a nuclear bomb explosion is not comparable to clean up after a nuclear reactor accident; Entergy’s apparent assumption that the two are comparable severely underestimated cleanup costs. Nuclear explosions result in larger-sized radionuclide particles; reactor accidents release small sized particles. Decontamination is far less effective, or even possible, for small particle sizes. Nuclear reactor releases range in size from a fraction of a micron to a couple of microns; whereas nuclear bomb explosions fallout is much larger- particles that are ten to hundreds of microns. These small nuclear reactor releases can get wedged into small cracks and crevices of buildings. WASH-1400’s nuclear weapon clean up experiments involved cleaning up fallout involving large mass loading where there was a small amount of radioactive material in a large mass of dirt and demolished material. Only the bottom layer will be in contact with the soil and the massive amount of debris can be swept up with brooms or vacuums resulting in a relatively effective, quick and cheap cleanup that would not be the case with a nuclear reactor’s fine particulate. A weapon explosion results in non-penetrating radiation so that workers only require basic respiration and skin protection. This allows for cleaning up soon after the event. In contrast a reactor release involves gamma radiation and there is no gear to protect workers from gamma radiation. Therefore cleanup cannot be expedited and decontamination is less effective with the passage of time.

the atomic reactors are operating. Judge Higuchi had previously ordered that the Ohi nuclear plant in Fukui also remain closed for the same reason. Judge Higuchi's Takahama order overruled Japan's Nuclear Regulation Authority's decision to restart under revised regulatory standards. In spite of the Abe government's push to restart atomic power, Japan remains "Zero Nuclear" by popular demand and legal authority.

The court order occurs as TEPCO officials admit that environmental cleanup of the Fukushima Daiichi disaster is centuries away. **Naohiro Masuda** and **Akira Ono**, two top-level TEPCO senior managers charged with "decommissioning" the three melted Fukushima reactors say that a myriad of extremely complex and unproven technologies for removing, cleaning up and managing the melted reactor cores does not currently exist and "cannot say it is possible."

Dale Klein, a former U.S. Nuclear Regulatory Commission Chair and now TEPCO's chief apologist for the bankrupt corporation's reactor restart committee, also admitted that a cleanup technology is non-existent. He and TEPCO however continue to hold out hope that robotic technology can eventually be developed to clean up the radioactive site which accumulates hundreds of tons of radioactive water each day.

Meanwhile, the latest in state-of-the-art robotic technology commissioned to locate one of melted cores had to be **abandoned by TEPCO** after it failed three hours on its journey into the wreckage. The globally touted snake-like robot technology shut down before it could gather any information on the still missing and uncontained core material somewhere under Unit 1.

8. PRAs Minimize Health Costs & Evacuation Time Estimates

The health costs resulting from a severe accident directly depend on who was exposed and for how long, and the latter in turn depends on whether evacuation was timely and successful.

Evacuation Time Estimates (ETEs): With no apparent complaint from the NRC, licensees consistently use faulty, in some cases almost ludicrous, assumptions about who should evacuate and how long it will take them (to say nothing of the far greater number of individuals who will, and in many cases probably should, try) to evacuate. Pilgrim's 2012 KLD Evacuation Time Estimate unrealistically concluded that the entire EPZ would be evacuated in (6) hours¹²¹. If realistic evacuation times and assumptions regarding evacuation were used, the analyses would show far fewer will evacuate in a timely manner, and the inevitable result will be increased health-related costs.

The standard KLD time estimates used are based on NUREG/CR-7002 and telephone surveys. These documents contain multiple incorrect assumptions. Examples include: the population will follow a staged evacuation ignoring the public's almost instant ability to communicate; a straight-line Gaussian plume defines the evacuation "keyhole" where the public knows winds are variable and will act; accordingly, and they assume only a 20% shadow evacuation out to 15 miles from reactor and the rest of the population will not attempt to evacuate. The Cape Cod Telephone Survey showed that 70% would evacuate if they were told that there was a disaster at Pilgrim and 50% if they were told not to evacuate. The respondents went out 25 miles, not 15 miles. ¹²²

¹²¹ KLD Pilgrim Evacuation Estimate December 12, 2012, Final Report KLD-TR-510, NRC Electronic Library ADAMS, Accession Number ML13023A031

¹²² KLD MEMO to John Giarrusso (MEMA) from Chris Chaffee (KLD) Regarding the Cape Cod Telephone Survey Results, July 25, 2013

Further the KLD's do not take into consideration the many variables that would slow evacuation: shadow evacuation; evacuation time estimates during inclement weather coinciding with high traffic periods such as commuter traffic, traffic during peak commute times, holidays, summer beach/holiday traffic; notification delay delays because notification is largely based on sirens that cannot be heard indoors above normal ambient noise with windows closed or air conditioning systems operating.

Health Effects Radiation: Having artificially reduced the potential number of potentially effected (not only through inaccurate evacuation times but also by assuming that only those in a small geographic area will potentially be effected and only for a short time), the NRC economic consequences analysis goes on intentionally to further underestimate the cost, not only in dollars but also in human suffering.

The effects of radiation exposure on public health after an accident rarely are immediately evident. The latency period for cancers, diseases and reproductive disorders extends over many years. Lessons learned from previous accidents and the most recent report by the National Academies of Sciences (BEIR VII), and studies by Cardis and the Techna River Cohort, all show that the assumptions in the MACCS2 concerning health impact are outdated and underestimate health effects.

a. **Value of Life:** The value the assigned to life is far lower than other federal agencies. Other agencies value a life at \$ 5-9 million. For example EPA values a life lost at \$6.1 million (U.S.E.P.A., 1997, The Benefits and Costs of the Clean Air Act, 1970 to 1990, Report to US Congress (October), pages 44-45). The GAO reported that it is hard to justify below \$5 million whereas NRC remains at \$3 million. If NRC raised its valuation then more retrofits would be justified.

b. **\$2000/person-rem conversion rate:** The population dose conversion factor of \$2000/person-rem used by licensees in the code, and allowed by NRC, to estimate the cost of the health effects generated by radiation exposure is based on a deeply flawed analysis and seriously underestimates the cost of the health consequences of severe accidents.

This conversion factor is inappropriate. It does not consider the significant loss of life associated with early fatalities from acute radiation exposure that could result from some severe accident scenarios. Neither does it properly estimate the generation of stochastic health effects by failing to consider the fact that some members of the public exposed to radiation after a severe accident will receive doses above the threshold level for application of a dose- and dose-rate reduction effectiveness factor (DDREF).

The NRC approved \$2000/person-rem conversion factor is apparently intended to represent the cost associated with the harm caused by radiation exposure with respect to the causation of "stochastic health effects," that is cancers and not deterministic effects, commonly known as radiation sickness¹²³. The value was derived by NRC staff by dividing the Staff's estimate for the value of a statistical life, \$3 million (presumably in 1995 dollars, the year the analysis was published) by a risk coefficient for stochastic health effects from low-level radiation of 7×10^{-4} /person-rem, as recommended in Publication No. 60 of the International Commission on Radiological Protection (ICRP). (This risk coefficient includes nonfatal stochastic health effects in addition to fatal cancers.) But the use of this conversion factor in SAMA analyses is inappropriate in two key respects and thus underestimates the health-related costs associated with severe accidents.

First, the \$2000/person-rem conversion factor is specifically intended to represent only stochastic health effects (e.g. cancer), and not deterministic health effects "including early fatalities which could result

¹²³ U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy," NUREG-1530, 1995, p. 12

from very high doses to individuals.”¹²⁴ However, for some of the severe accident scenarios evaluated, large numbers of early fatalities could occur representing a significant fraction of the total number of projected fatalities, both early and latent. This is consistent with the findings of the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437).¹²⁵ Therefore, it is inappropriate to use a conversion factor that does not include deterministic effects. Per NRC’s guidance, “the NRC believes that regulatory issues involving deterministic effects and/or early fatalities would be very rare and can be addressed on a case-specific basis, as the need arises.”¹²⁶ How for example can this be justified in a spent fuel pool fire accident?

Second, the \$2000/person-rem factor, as derived by NRC, also underestimates the total cost of the latent cancer fatalities that would result from a given population dose because it assumes that all exposed persons receive dose commitments below the threshold at which the dose and dose-rate reduction factor (DDREF) (typically a factor of 2) should be applied. However, for certain severe accident scenarios considerable numbers of people would receive doses high enough so that the DDREF should not be applied.¹²⁷ This means, essentially, that for those individuals, a one-rem dose would be worth “more” because it would be more effective at cancer induction than for individuals receiving doses below the threshold. To illustrate, if a group of 1000 people receive doses of 30 rems each over a short period (population dose 30,000 person-rem), 30 latent cancer fatalities would be expected, associated with a cost of \$90 million, using NRC’s estimate of \$3 million per statistical life and a cancer risk coefficient of 1×10^{-3} /person-rem. If a group of 100,000 people received doses of 0.3 rem each (also a population dose of 30,000 person-rem) a DDREF of 2 would be applied, and only 15 latent cancer fatalities would be expected, at a cost of \$45 million. Thus, a single cost conversion factor, based on a DDREF of 2, is not appropriate when some members of an exposed population receive doses for which a DDREF would not be applied.

A better way to estimate the cost equivalent of the health consequences resulting from a severe accident would be simply to sum the total number of early fatalities and latent cancer fatalities, as computed by the MACCS2 code, and multiply by not a \$3 million figure but a higher life valuation, in line with other federal agencies. It is not reasonable to distinguish between the loss of a “statistical” life and the loss of a “deterministic” life when calculating the cost of health effects. The NRC does so. Why? The only apparent reason is to save the industry money.

c. **Health Impacts Ignored:** Wrongly, the NRC analysis does not even consider cancer incidence. Neither does it consider many other potential health effects from exposure in a severe radiological event (National Academy of Sciences, BEIR VII Report, 2005).

d. **Recent Studies Ignored:** The NRC’s SAMA analyses need to be based on current research. Recent studies published on radiation workers (Cardis et al. 2005¹²⁸) and by the Techa River cohort

¹²⁴ U.S. NRC (1995), op cit., p. 1.

¹²⁵ U.S. NRC, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Vol. 1, May 1996, Table 5.5.

¹²⁶ U.S. NRC, “Reassessment of NRC’s Dollar Per Person-Rem Conversion Factor Policy (1995), op cit., p. 13.

¹²⁷ The default value of the DDREF threshold is 20 rems in the MACCS2 code input

¹²⁸ Elizabeth Cardis, “Risk of cancer risk after low doses of ionising radiation: retrospective cohort study in 15 countries.” *British Medical Journal* (2005) 331:77. Referenced Beyea

(Krestina et al (2005¹²⁹) show a marked increase in the value of cancer mortality risk per unit of radiation at low doses (2-3 rem average). Both studies give similar values for low dose, protracted exposure, namely (1) cancer death per Sievert (100 rem). Using the results of the study by Cardis et al. and use of the risk numbers derived from the Techa River cohort several additional SAMAs would become cost effective.

e. **Indirect health costs ignored:** They include, for example, medical expenditures for treatment, losses in time and economic productivity, liability resulting from radiation health related illness and death, and caregivers evacuating and leaving patients unattended, as at Fukushima. These are economic consequences.

9. PRAs Ignore Additional Economic Consequences

Lessons learned from Fukushima demonstrate that the MACCS2's assumptions of what economic variables to model are too limited and serve to underestimate offsite economic consequences. In addition to those already discussed, any realistic analysis of economic consequences would have to consider the following.

a. Indirect economic effects or the "multiplier effects ignored:" Depending on the business done inside the building contaminated, the regional and national economy could be negatively impacted. A resulting decrease in the area's real estate prices, tourism, and commercial transactions could have long-term negative effects on the region's economy.

b. Economic infrastructure ignored: The MACCS2 considers the costs of farm and non-farm decontamination and the value of farm and nonfarm wealth; however, nowhere in the economic consequences analysis is there any discussion of the loss of, and costs to remediate the economic infrastructure that make business, tourism, and other economic activity possible. Economic infrastructure is the basic physical and organizational structures needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function. The term typically, and as used by PW, refers to the technical structures that support a society, such as roads, water supply, sewers, power grids telecommunications, and so forth. Viewed functionally, infrastructure *facilitates* the production of goods and services; for example, roads enable the transport of raw materials to a factory, and also for the distribution of finished products to markets. Also, the term may also include basic social services such as schools and hospitals.

c. Other economic costs ignored: The economic consequences should, but do not, include the business value of property and the incurred costs such as costs required from job retraining, unemployment payments, and inevitable litigation. Further, one of the cited general criticisms of the MACCS2 Code is that "the economic model included in the code models only the economic cost of mitigative actions."¹³⁰

10. PRAs Allow User to Manipulate the Code

¹²⁹ Krestinina LY, Preston DL, Ostroumova EV, Degteva MO, Ron E, Vyushkova OV, et al. 2005. Protracted radiation exposure and cancer mortality in the Techa River cohort. *Radiation Research* 164(5):602-611.

¹³⁰ 1997 MACCS2 User Guide

The MACCS2 code used by industry (with the NRC's approval) to model economic consequences of a severe accident is, at best severely limited in what it can do and what it cannot. Even in those areas where the MACCS2 code has some capability, the NRC cannot continue to allow industry to manipulate the way in which it uses the code to intentionally minimize potential consequences; ignore real health costs; create essentially useless evacuation time estimates; choose the input parameters into the model; and choose to average the code's inputs by a mean and not the 95th percentile.

In order to ensure realistic cost-benefit analyses, the NRC cannot continue to allow as a matter of policy licensees to choose how they will use the MACCS2 code. Section 6.10 of the 1997 User Guide, Generation of Consequence Distributions, explains. It says, "Under the control of parameters supplied by the user on the EARLY and CHRONC input files, the EARLY and CHRONC modules can calculate a variety of different consequence measures to portray the impact of a facility accident on the surrounding region. *The user has total control over the results that will be produced.*"¹³¹ (Emphasis added)

11. MACCS2 Computer Code Used in PRA's Not Quality Assured.¹³²

The MACCS & MACCS2 codes were developed for research purposes not licensing purposes –for that reason they were not held to the QA requirements of NQA-a (American Society of Mechanical Engineering, QA Program Requirements for Nuclear Facilities, 1994). Rather they were developed using the less rigorous QA guidelines of ANSI/ANS 10.4. [American Nuclear Standards Institute and American Nuclear Society, *Guidelines for the Verification and Validation of Scientific and Engineering Codes for the Nuclear Industry*, ANSI/ANS 10.4, La Grange Park, IL (1987). Further the biggest reason for *not* using the MACCS2 economic cost model is that there is no written explanation of *exactly* how it works, and how it interacts with the long-term dose accumulation models.

12. SOARCA Code Used in PRAs Unreliable

NRC developed this code to estimate offsite radiological health consequences for potential severe reactor accidents. SOARCA analyzed the potential consequences of severe accidents at the Surry Power Station near Surry, Va. and the Peach Bottom Atomic Power Station near Delta, Pa. Peach Bottom is a reactor like Pilgrim. It used the outdated and fundamentally flawed MACCS2 computer code and thus its main findings are not credible.

SOARCA concluded that:

- Existing resources and procedures can stop an accident, slow it down or reduce its impact before it can affect public health.
- Even if accidents proceed uncontrolled, they take much longer to happen and release much less radioactive material than earlier analyses suggested; and
- The analyzed accidents would cause essentially zero immediate deaths and only a very, very small increase in the risk of long-term cancer deaths.

¹³¹ User Guide for MACCS2, the Code Manual for MACCS2: Volume 1, User's Guide, SAND97-0594, which was written in 1997. Chanin, D.I., and M.L. Young, Code Manual for MACCS2: Volume 1, User's Guide, SAND97-0594 Sandia National Laboratories, Albuquerque, NM, (1997)

¹³² Chanin, D.I. (2005), "The Development of MACCS2: Lessons Learned," [written for:] *EFCOG Safety Analysis Annual Workshop Proceedings*, Santa Fe, NM, April 29–May 5, 2005. Full text: [the development of maccs2.pdf](http://chaninconsulting.com/index.php?resume) (154 KB), revised 12/17/2009. <http://chaninconsulting.com/index.php?resume>.

The findings are not credible for all the reasons discussed in the foregoing. Unfortunately, SOARCA is being relied upon by the NRC today. For example, NRC staff's current recommendation to the NRC Commission to not require filters on vents, a reversal of its previous recommendation, is based on SOARCA. Not only are SOARCA's conclusions not credible but the code does not look at offsite economic consequences in a severe accident.

DECISION TO CLOSE PILGRIM

- **PILGRIM – ECONOMICS – COULD NOT COMPETE WITH CHEAPER ENERGY**
- **PILGRIM POOR MANAGEMENT & OVERSIGHT LED TO HIGH OPERATING COSTS**

IMPACTS CLOSURE

- **PLYMOUTH'S AND S.E. REGION'S ECONOMY**
- **DO WE NEED PILGRIM'S POWER TO KEEP THE LIGHTS ON?**
- **ADDRESSING CLIMATE CHANGE**



Decision To Close Pilgrim- Economics

Entergy Press Release: Entergy to Close Pilgrim Nuclear Power Station in Massachusetts No Later than June 1, 2019¹³³

Decision driven by low energy prices, little expectation of near-term market structure improvements and increased operational costs.

NEW ORLEANS – Entergy Corporation (NYSE: ETR) announced today that it will close its Pilgrim Nuclear Power Station in Plymouth, Mass., no later than June 1, 2019, because of poor market conditions, reduced revenues, and increased operational costs. The company notified the independent system operator of the electric grid, the ISO New England Inc. (ISO-NE) that as of that date Pilgrim would not participate as a capacity resource in the market. The exact timing of the shutdown depends on several factors, including further discussion with ISO-NE, and will be decided in the first half of 2016.

“The decision to close Pilgrim was incredibly difficult because of the effect on our employees and the communities in which they work and live,” said Leo Denault, Entergy’s chairman and chief executive officer. “Our people at Pilgrim are dedicated and skilled, a wonderful blend of young professionals and seasoned, experienced veterans, who for decades have been generating clean power and contributing millions of dollars of economic activity to the region. But market conditions and increased costs led us to reluctantly conclude that we had no option other than to shut down the plant.”

¹³³ <http://www.pilgrimpower.com/operational-update/>

Please click here for the full [press release](#).

Please click here for the [press conference audio recording](#) from October 13, 2015.

Please click here for the [presentation slides](#) from the press conference.

Entergy Questions & Answers¹³⁴

When will Pilgrim Station close?

Our intent is for Pilgrim to meet our ISO-NE capacity obligations through May 31, 2019 and then no longer participate as a capacity resource in the market.

Factors that could lead us to shut down earlier than 2019, such as at the end of our current operating cycle in 2017, include: 1) increased cost of regulatory recovery, 2) any additional regulatory challenges stemming from operational issues, and 3) potential opportunities to find economically viable sources of capacity to replace that which Pilgrim is obligated to supply. The exact timing of the shutdown also depends on further discussion with the ISO-NE and will be decided in the first half of 2016.

As we have always stated, the company regularly evaluates its portfolio of assets and considers all options to determine what's best for each, and the company and its stakeholders. We use a disciplined approach of constantly evaluating our portfolio of assets to determine next steps, which could include retaining, selling, or closing facilities.

Why was this decision made?

We intend to shut down Pilgrim because low current and forecast energy prices and a distorted wholesale energy market, along with increased costs, make the plant's continued operation not economically viable.

Low current and forecast wholesale energy prices -- brought about by record low natural gas prices, driven by shale gas production -- significantly impacted Pilgrim's revenues. The market price for delivered natural gas in New England has dropped substantially because of the influx of shale gas and policy-related issues, and that in turn has driven down power prices. Current and forecast power prices have fallen about \$10 per megawatt hour, an annual loss of over \$40 million in revenues for Pilgrim.

Wholesale energy market design flaws continue to suppress energy and capacity prices in the region, and do not provide adequate compensation to merchant nuclear plants for the benefits they provide. These benefits include onsite fuel storage, reliability, carbon-free, and large-scale 24/7 energy generation. Efforts to correct these market design flaws are too slow in coming to reverse the harm. Looking ahead, unfavorable state energy proposals include efforts to subsidize renewable energy sources at the expense of Pilgrim, provide above-market prices for hydro power to utilities in Canada serving about one-third of Massachusetts' electricity demand, and a recent order which would further lower the price of natural gas and increase the region's reliance on it.

We have already invested hundreds of millions of dollars to improve the plant's safety, reliability and security but face increased operational costs and enhanced NRC oversight. While we will always make needed investments at any plant, we also consider the effect on our stakeholders of operating over the long-term if it is not economically viable to do so.

What are the factors in your decision on whether to shut down prior to 2019?

¹³⁴ Ibid

Pilgrim has an agreement with ISO New England to be available to supply electricity (a Capacity Services Obligation), either by operating Pilgrim or via some other mechanism, until May 31, 2019.

While we intend to meet our current capacity obligations to ISO-NE, based on several factors we could determine it makes the most sense to our broad group of stakeholders to shut down the plant at the end of its current operating cycle, in 2017.

Factors that could lead us to shut down earlier than 2019, such as at the end of our current operating cycle in 2017, include: 1) increased cost of regulatory recovery, 2) any additional regulatory challenges stemming from operational issues, and 3) potential opportunities to find economically viable sources of capacity to replace that which Pilgrim is obligated to supply.

If Pilgrim operates until May 2019, it will need to conduct a refueling outage in the spring of 2017. We will decide by the first half of 2016 whether to proceed with the 2017 refueling outage (and thus continue to operate until 2019).

By what date would the company need to decide on whether to refuel in 2017?

We will decide in the first half of 2016. Pilgrim refueled in 2017.

Massachusetts electricity deregulation and retail access officially began back in March of 1998. Before deregulation, Pilgrim was owned by Boston Edison and was part of a utility-owned network of power plants. In a regulated market, utilities passed along their combined costs to consumers in a single monthly charge.

Entergy believed that they could make a large profit buying up reactors in newly deregulated markets and purchased Pilgrim and other reactors. But in deregulated markets generators must compete on a stand-alone basis by selling electricity to utilities and other suppliers through daily auctions that tap the cheapest resources capable of satisfying grid needs. In recent years, plunging natural gas and wind prices have forced wholesale power prices down, making it hard for reactors in deregulated (competitive) markets to compete. This is especially so for older reactors facing rising operating and capital costs related to age and Nuclear Regulatory Commission post-Fukushima required fixups. Vermont Yankee, operating in the same market as Pilgrim, closed when it became unprofitable to operate. Entergy announced in 2015 that economics was driving its consideration of closing its Fitzpatrick reactor in New York and announced closure of Pilgrim by June 1, 2019 on October 13, 2015.

Pilgrim's Closure- Handwriting was on the wall: September 24, 2015, UBS downgraded Entergy Corp to sell, noting that Entergy's stock has fallen 30% this year.¹³⁵ UBS said that, "After the latest disclosures of potential early retirements of Fitzpatrick (838MW) and Pilgrim (688MW) we are increasingly concerned about the unregulated plant value... (and)... Following the NRC's downgrade of the Pilgrim plant we see a potential material increase in compliance/remediation costs as increasing discussion of early retirement into the next refueling in Spring 2017." The UBS report, *The Nuke Retirements are Coming* (September 2015) estimated that Pilgrim is slated to lose \$25 million this year and about \$60 million during the next four years.¹³⁶

¹³⁵ <http://www.streetinsider.com/dr/news.php?id=10916708>

¹³⁶ <https://neo.ubs.com/shared/d1TImFNvvySXa/>

Will Entergy Invest in Pilgrim now it announced a closure date? Will the parent corporation or its subsidiaries pitch in? No, Entergy is a complex web of limited liability companies.

Pilgrim's decision to close driven also by Entergy's poor management and oversight that led to high operating costs¹³⁷ Ineffective management and oversight is the surest way to increase operating and maintenance costs unnecessarily. Entergy's ineffective management and NRC's poor oversight led to Pilgrim's performance dropping to Column 4 that was estimated to carry a price tag of \$100 to \$300 million. The NRC put Pilgrim into Column 4 because its owner, Entergy, "had not adequately evaluated the causes of [unplanned shutdowns] and that some corrective actions had not been completed as intended or were closed out prematurely." It was ineffective management (by Entergy) and at last good oversight (by the NRC) that cost Pilgrim big money. Entergy could have avoided facing spending millions of dollars remediating poor performance and being offline not generating electricity and money had it maintained its aging reactor all along.

As the Pilgrim ages, it requires more investment. But it was ignored resulting in lengthy and expensive shutdowns. For example, Pilgrim was in full shutdown for 55 days since Jan. 1. Pilgrim generates an average of about \$1.1 million in gross revenue per day and about \$569,000 after all the bills are paid, based on figures from ISO-New England and data from SNL Energy, a data and analysis resource for the utility industry.

Pilgrim's Closure - Economic Impact Plymouth & Region

Plymouth regards Pilgrim as vital to its economy; Plymouth has not put money aside to cushion the blow when Pilgrim retires so taxes will rise inevitably.

The Pilgrim Nuclear Power Station Study A SOCIO-ECONOMIC ANALYSIS AND CLOSURE TRANSITION GUIDEBOOK, Jonathan Cooper, Univ. Massachusetts-Amherst (April 2015)¹³⁸ was commissioned by the Town of Plymouth to determine for the town the economic impact of Pilgrim closing. The study did not analyze the economic impact of delayed decommissioning versus Safstor, deferred decommissioning.

The report's significant findings:

Pilgrim Station is a vital part of a regional economy that lags 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.

¹³⁷ <http://allthingsnuclear.org/pilgrims-shutdown-little-mo-yields-big-om/>

¹³⁸ http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1080&context=larp_ms_projects

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. UNIVERSITY OF Pilgrim Station's non-payroll expenditures were approximately \$77.5 million and provided a substantial source of revenue to local businesses and municipalities. MAS 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 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. Nuclear power plant employment is stable and well-compensated, enabling employees to attain home ownership.

Closure Impacts, Section 4.3 of the report:

Pilgrim Station's direct and secondary impacts bring several 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.

In summary:

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 athan G. Cooper

Pilot Agreement between Entergy and Pilgrim:¹³⁹ Annual payments from Entergy to Plymouth depend on operations.

NOW, THEREFORE, Entergy and the Town stipulate and agree as follows:	
1. <u>Annual Payments.</u> Entergy and the Town agree that the respective annual payments due for Fiscal Years 2014 through 2016 ("Annual Payments") shall be as follows:	
Fiscal Year	Payment
2014	\$10,000,000
2015	\$9,500,000
2016	\$9,250,000

Pilgrim's Importance To New England's Power

We do not need Pilgrim's power to keep the lights on; ISO New England (the Regional Transmission Organization, serving New England) predicts new and older nuclear generators may be needed in the future during peak winter and summer times without timely investment to expand natural gas or LNG infrastructure.

ISO New England 2017 Regional Electricity Outlook¹⁴⁰ shows the role nuclear plays in the region's power. In 2016, nuclear contributed 31% of the entire region's power. (ISO 2017 report at 8)

¹³⁹http://www.plymouth-ma.gov/sites/plymouthma/files/uploads/2013_08-13_-_pilot_agreement_with_entergy.pdf

¹⁴⁰ https://www.iso-ne.com/static-assets/documents/2017/02/2017_reo.pdf

The report examines the impact of the closure of oil, coal, and nuclear generators in the region. It explained (at 27) that:

About 4,200 MW— an amount equal to almost 15% of the region’s current generating capacity—will have shut down between 2012 and 2020 and is being replaced primarily by new natural-gas-fired plants. The upcoming closures of just two of those resources—Brayton Point Station in May 2017 and Pilgrim Nuclear Power Station by May 2019—will remove 2,200 MW of non-gas-fired capacity. Over 5,500 MW of additional oil and coal capacity are at risk for retirement in coming years, and uncertainty surrounds the future of 3,300 MW from the region’s remaining nuclear plants. (ISO at 27)

Major Generator Retirements Limit the ISO’s Options for Meeting Winter and Peak Demand

Nuclear power typically provides around 30% of the region’s energy. Coal- and oil-fired resources, despite providing only about 3% of the region’s electricity last year, can also make valuable contributions on the coldest days of winter, as well as on the hottest days of summer when demand is very high or major resources are unavailable. For example, on the 2016 summer peak day shown below, a nuclear generator was unexpectedly offline, and coal and oil filled the gap. Within a decade, though, the region may have little to no generating capacity left fueled by coal and oil and is also at risk of losing more nuclear generators. (ISO 2017 report at 28)

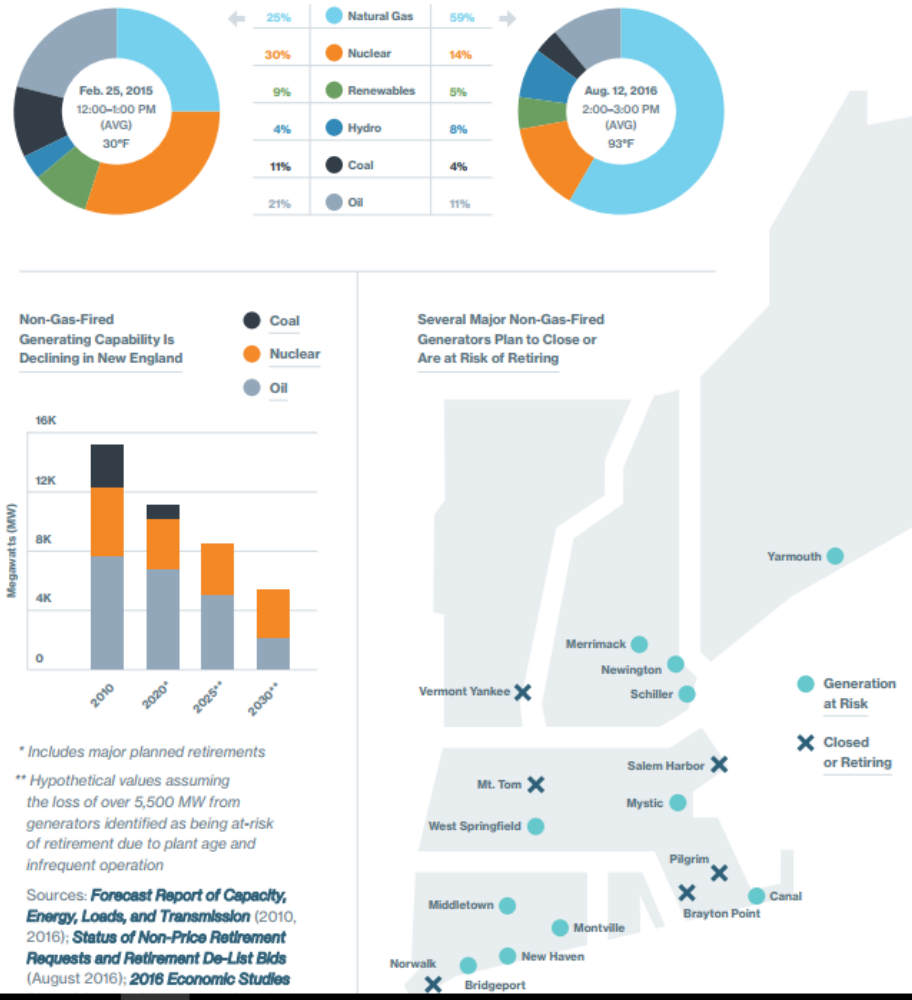
As of September 2017, New England faces an oversupply of electric generation due to natural gas and a slightly reduced demand. But the market profile is likely to change with the retirements of coal, oil and closure of Vermont Yankee and Pilgrim.¹⁴¹ The following chart from ISO (at 29) shows the role of major generator retirements.

¹⁴¹ Could Success Spoil ISO-NE? Power Magazine, Kennedy Maize, 09.01.17 <http://www.powermag.com/could-success-spoil-iso-ne/>

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Non-Gas-Fired Resources Are Critical During Winter and Peak Summer Days



The report at 29, does not believe that adding more renewables will help during winter. It explained that:

Wind and solar resources can offset some natural gas use, but their help is limited by still-low levels of regional installation. Additionally, wind speeds are variable and can drop during extreme cold snaps, paradoxically creating a need for natural-gas-fired generators that can ramp up and down quickly to balance fluctuations in supply or demand and maintain continuity of electricity supply. Solar energy, meanwhile, isn't dispatchable by the ISO and doesn't help meet peak winter demand, which happens after the sun has set. Moreover, winter conditions, with snowfall and fewer daylight hours, also dampen solar output. Extreme cold could also reduce imported Canadian hydropower through proposed new long-distance transmission lines because Canada is a winter-peaking system and may need the power itself.

ISO at 31, concluded that:

Without timely investment to expand natural gas or LNG infrastructure, the region should expect significant energy market price volatility when the gas pipelines are constrained. Plus, the region may soon be forced to take stronger—and likely costly—steps. The first step will be to further strengthen market incentives for generators to contract for fuel. As a last resort, the ISO may be forced into retaining some non-gas-fired generators that may be older, expensive, and higher-emitting—a strategy that runs counter to the states’ ambitious carbon-reduction goals.

Climate Change: Pilgrim’s Role In Reducing Carbon Emissions

Massachusetts Addresses Climate Change¹⁴²

On May 17, 2016, the Supreme Judicial Court of Massachusetts ruled that the Massachusetts Global Warming Solutions Act (GWSA) requires MassDEP to promulgate new regulations that “impose a limit on [greenhouse gas] emissions that may be released, limit the aggregate emissions released from each group of regulated sources or categories of sources, set emission limits for each year, and set limits that decline on an annual basis” to meet the requirements of Section 3(d) of Chapter 21N of the General Laws.

On September 16, 2016, Governor Baker signed Executive Order 569  which directed the Executive Office of Energy and Environmental Affairs to coordinate and make consistent new and existing efforts to mitigate and reduce greenhouse gas emissions and to build resilience and adapt to the impacts of climate change. The Executive Order also directed MassDEP to promulgate regulations that satisfy the mandate of Section 3(d) by August 11, 2017, with the objective that these regulations ensure that the Commonwealth meets the 2020 statewide emissions limit mandated by the GWSA.



¹⁴² <http://www.mass.gov/eea/agencies/massdep/air/climate/section3d-comments.html>

DEP decides Pilgrim not eligible for Massachusetts Clean Energy Credits (CES)

The Massachusetts Department of Environmental Protection (MassDEP) finalized a new regulation August 11, 2017, to increase the percentage of electricity sold to consumers in Massachusetts that is generated using clean energy – defined as carbon free.¹⁴³ It requires electricity generators to annually demonstrate the use of carbon-free energy to generate a specified percentage of their electricity sales - for which it gets clean energy credits (CES). A generator can meet its specified percentage by producing clean energy itself or by purchasing credits from other generators.

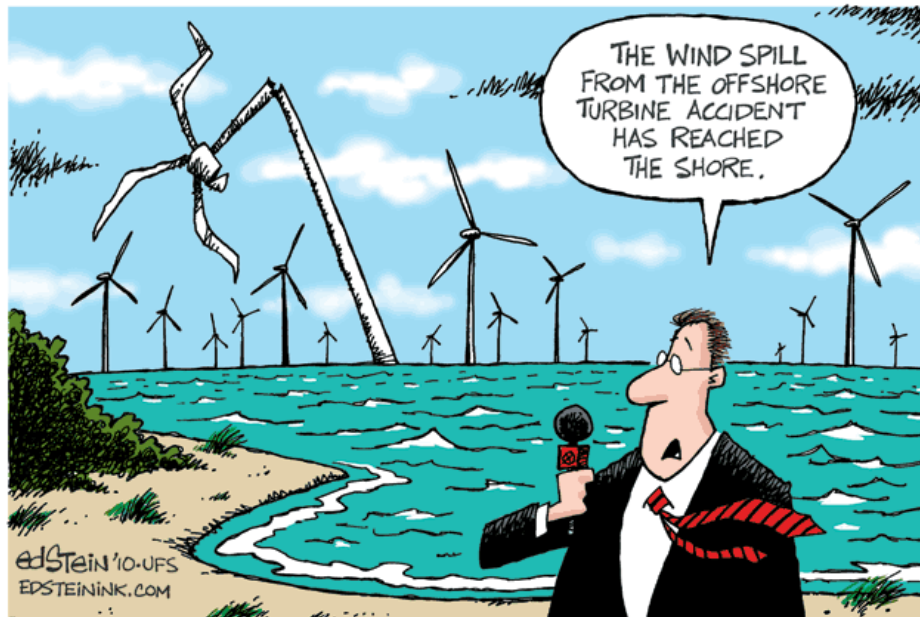
The primary purpose of the clean energy regulation is to enable Massachusetts to meet its carbon reduction goals by encouraging development of new low and zero-carbon emissions generation technologies. To achieve this goal, the regulation's requirement that, for a generator to qualify as a clean generation unit, its initial commercial operation date shall be after December 31, 2010. Pilgrim went online in 1972.

Mass DEP recognized in August 2017 that giving CES credits to existing power generators would not provide an incentive to reduce emissions. Pilgrim, for example, is a large generator that could earn a huge number of carbon-free credits. It likely would sell those credits to the dirtiest existing carbon-producing polluters so that they could meet their clean-energy requirement while continuing indefinitely to pollute our atmosphere. Giving credits to Pilgrim would provide it with a windfall subsidy and would discourage the development here of new low and zero-carbon generators.

If Massachusetts had given Pilgrim credits, Entergy may have changed its mind about closing Pilgrim in 2019 and decide to continue operating Pilgrim itself or to sell it to some other nuclear company such as Exelon. That is exactly what Entergy did in New York. It announced that Fitzpatrick (a nuclear reactor like Pilgrim) would be closed in 2017. Then, when New York decided to give credits to Fitzpatrick, it abandoned any plans to close and sold Fitzpatrick to Exelon that plans to continue operation. The same thing happened in Illinois.

Nuclear Reactors Are Not The Answer to Climate Change

¹⁴³ Ibid



Do you worry about a terrorist attacking a wind turbine?

A FACT Sheet Prepared By The Nuclear Information Resource Service, Takoma Park, Maryland
<http://www.nirs.org/factsheets/nukesclimatefact614.pdf> summarizes why nuclear reactors are not the answer to climate change

TOO MANY REACTORS, NOT ENOUGH CARBON REDUCTIONS: Major studies (from MIT, Commission on Energy Policy, and International Atomic Energy Agency, for example) agree that about 1,500-2,000 large new atomic reactors would have to be built worldwide for nuclear power to make any meaningful dent in greenhouse emissions (less than 400 reactors now operate globally). If all of these reactors were used to replace coal plants, carbon emissions would drop by about 20% worldwide. If used entirely as new capacity instead of sustainable technologies like wind power, solar power, energy efficiency, etc., carbon emissions actually would *increase*.

TOO MUCH MONEY: Construction of 1,500 new reactors would cost trillions of dollars. New reactors cost some \$7 billion to \$15 billion each. Use of resources of this magnitude would make it impossible to also implement more effective means of addressing global warming. Energy efficiency improvements, for example, are some seven times more effective at reducing greenhouse gases, per dollar spent, than nuclear power.

TOO MUCH TIME: Construction of 1,500 new reactors would mean opening a new reactor about once every two weeks, beginning today, for the next 60 years—an impossible schedule and even then too late to achieve necessary carbon reductions. The world's nuclear reactor manufacturers currently are capable of building less than half that amount. Since reactors take 6-10 years to build (some U.S. reactors that began operation in the 1990s took more than 20 years), a nuclear climate plan is already years behind schedule and would fall farther behind. Addressing the climate crisis cannot wait for nuclear power.

NEW REACTOR DESIGNS: TOO SLOW, NO DEMAND: Some otherwise knowledgeable climate scientists advocate using new, supposedly safer, reactor designs as a climate solution. These

untested designs, such as the IFR (Integral Fast Reactor), PBMR (Pebble Bed Modular Reactor), thorium reactors and others, including “small modular reactors, won’t help either. The designs—all of which have been around for decades—exist only on paper and it would take decades to bring them to commercial operation. To achieve even that would require utilities to want to build them, but none do. Their costs would be even higher than current reactor designs—one reason utilities aren’t interested. Safety-wise, the designs are unproven and would require extensive and time-consuming testing before the federal Nuclear Regulatory Commission could license them. Waiting for such reactors to materialize would forestall much faster and cheaper climate solutions.

TOO MUCH WASTE: Operation of 1,500 or more new reactors would create the need for a new Yucca Mountain-sized radioactive waste dump somewhere in the world every 3-4 years. Yucca Mountain was under study for nearly 20 years and was dropped by President Obama as a non-viable waste solution. International efforts to site radioactive waste facilities are similarly behind schedule and face substantial public opposition. For this reason, the U.S. and other countries are attempting to increase reprocessing of nuclear fuel as a waste management tool—a dangerous and failed technology that increases nuclear proliferation risks.

TOO LITTLE SAFETY: Odds of a major nuclear disaster are said to be on the order of 1 in 10,000 reactor-years, but experience shows accidents occur even more frequently. Operation of some 1,500 reactors could result in a Fukushima-scale nuclear accident every five years—a price the world is not likely to be willing to pay. And more reactors mean more potential terrorist targets.

TOO MUCH BOMB-MAKING MATERIALS: Operation of 1,500 or more new reactors would require a dozen or more new uranium enrichment plants and would result in the production of thousands of tons of plutonium (each reactor produces about 500 pounds of plutonium per year), posing untenable nuclear proliferation threats.

NUKES ARE NOT CARBON-FREE: While atomic reactors themselves are not major emitters of greenhouse gases, the nuclear fuel chain produces significant greenhouse emissions. Besides reactor operation, the chain includes uranium mining, milling, processing, enrichment, fuel fabrication, and long-term radioactive waste storage, all of which are essential components of nuclear power. At each of these steps, transport, construction and operation of nuclear facilities results in greenhouse gas emissions. Taken together, the fuel chain greenhouse emissions are more than double solar power emissions and some six times higher than wind power—not to mention emissions-free energy efficiency technologies.

NOT SUITED FOR WARMING CLIMATES: Unlike solar power, nuclear power does not work well in warming climates. Reactors require vast quantities of water to keep their cores and steam condensers cool; changes in water levels, and even water temperatures, can greatly affect reactor operations. Reactors in the U.S. and elsewhere have been forced to close during heat waves, when they’re needed the most. Ever-stronger storms, like Hurricane Sandy, also threaten to inundate both coastal and inland reactors. More frequent and more powerful tornados, ice storms and related loss-of-power accidents, and other indicators of climate change also imperil reactors. The Fukushima accident was caused primarily by loss-of-power, not damage from the earthquake/tsunami. Rising sea levels threaten coastal

reactors with flooding even without mega-storms.

WHAT WE CAN DO:

A NUCLEAR-FREE, CARBON-FREE FUTURE: Most people don't realize just how fast clean renewable energy is growing nor how low its costs are plummeting. Just a few years ago, solar and wind power weren't competitive with either nuclear power or fossil fuels. Now, both are usually cheaper than the polluting power choices. Increasingly, it is both feasible and economical for homeowners to install their own solar power plants on their rooftops—a new solar rooftop system is installed in the U.S. every four minutes, a number that will reach every 90 seconds during 2016.

Smart grids, distributed generation and other 21st century technologies enable the large-scale use of renewables despite their intermittent nature. On one day in May 2014, 74% of Germany's power was provided by renewables, a level skeptics said could never be reached. And advances in battery and other electricity storage technologies mean that both rooftop solar and larger-scale renewable power plants increasingly and affordably provide power 24/7—just like the behemoth nuclear and coal “baseload” power plants of the 20th century.

Investing our resources in clean energy— renewables and energy efficiency—gives us much more bang for the buck: instead of a 20% reduction in carbon emissions with nuclear power, we can get a 100% reduction—and that's a goal worth working for. Numerous studies show conclusively that a nuclear-free, carbon-free energy system is both attainable and affordable before mid-century. Technology is not the issue; only political will stands in the way.

Our choice is stark: we can choose nuclear power, or we can address global warming. We can't do both. Fortunately, the choice is an easy one.

--Michael Mariotte, NIRS, June 2014

STATE AND PUBLIC PARTICIPATION

The Union of Concerned Scientists asked, *What can ... the public do to improve nuclear safety?* They quipped that, *"It sometimes seems that NRC stands for Nielsen Ratings Commission. Letters to the editor and letters to elected officials urging them to pressure the NRC to fix the safety problems it has identified will hasten progress down that path."*

The public, the Panel, the Governor, and the Attorney General should follow this advice and take advantage of NRC Rules provide for public participation via rulemaking, licensing, enforcement, and hearings. The following NRC links provide basic information: <http://www.nrc.gov/public-involve.html>

More important, likely with greater effect, the Commonwealth and the Town of Plymouth should exercise the powers they now have to take actions relative to operations and decommissioning. Their existing powers are considerably greater than many assume.

Although the Atomic Energy Act (AEA) gives the NRC authority and responsibility with respect to regulation of "the construction and operation of" a nuclear power plant, the NRC's exclusive authority is not unlimited. Rather, it extends *only* to the "field of nuclear safety regulation." *Pacific Gas & Elec. Co. v. State Energy Resources Conservation and Development Comm'n*, [461 U.S. 190](#), 216 (1983).

Contrary to what many apparently assume, Massachusetts and other states have the right to "regulate [nuclear] activities for purposes other than protection against radiation hazards." 42 USC Sec. 2021(k). "The [NRC]...does not purport to exercise its authority based on economic considerations... Congress intended the States to continue to make these judgments" (*Pacific Gas & Electric*, 461 U.S. at 207-208); and a state or local law grounded in economic purposes "lies outside the occupied field of nuclear safety regulation." (*Pacific Gas & Electric*, 461 U.S. at 216).

Massachusetts also has rights, delegated to it by Congress, under the Clean Air Act and Clean Water Act.

The basic legal principles, recently reaffirmed by Judge (now Justice) Gorsuch in *Cook v. Rockwell International Corp.*, 790 F.3d 1088 (10th Cir. 2015), are that a court should presume that there is no preemption, and that a court has a duty to read a statute in a way that disfavor's preemption, a duty that "is only 'heightened' where (as here) the area of law in question is one of traditional state regulation like public health and safety;" or, as in *Pacific Gas & Electric*, economics.

In short, Massachusetts has the right, and the public should lobby the Governor, Attorney General and the Great and General Court, to do what is needed, to ensure that Massachusetts interests are protected.

LINKS

Southeastern Massachusetts Groups Focused On Pilgrim

- Pilgrim Watch <http://www.pilgrimwatch.org/>
- Pilgrim Legislative Action Cooperative <http://www.plac-ma.org/>
- Pilgrim Coalition <http://www.pilgrimcoalition.org/>
- Cape Downwinders <http://www.capedownwinders.info/>
- Cape Downwinders Cooperative <http://capedownwinderscooperative.org/government/legislation/plac/>
- Down Cape Downwinders <https://www.facebook.com/Down-Cape-Downwinders-407255836063249/>
- Cape Cod Bay Watch <http://www.capecodbaywatch.org/>

Regional Groups

- C-10 Research and Education Foundation (Seabrook) <http://www.c-10.org/>
- Citizens Awareness Network (Vermont Yankee) <http://www.nukebusters.org/>
- New England Coalition (Vermont Yankee) <http://necnp.org/>
- Safe and Green Campaign (Vermont Yankee) <http://www.safeandgreencampaign.org/>

National Nuclear Safety Organizations

- Union Concerned Scientists http://www.ucsusa.org/nuclear_power/
- Beyond Nuclear <http://www.beyondnuclear.org/>
- Nuclear Information Service <http://www.nirs.org/>
- Institute of Energy and Environmental Research <https://ieer.org/>
- Bulletin of Atomic Scientists <http://thebulletin.org/>
- Fairewinds Energy Education <http://www.fairewinds.org/>
- Nuclear Decommissioning Citizen Advisory Panel -Vermont <http://publicservice.vermont.gov/electric/ndcap>

Government

- Nuclear Regulatory Commission <http://www.nrc.gov/>
- NRC Library (web based, includes hearing docket) <http://www.nrc.gov/reading-rm/adams.html>
- NRC Meeting Schedule <http://www.nrc.gov/public-involve.html>