Nuclear Power FAQ's

Nuclear power and radiation.

What is ionizing radiation and how is radiation a part of nuclear power?

Energy emitted from a source is generally referred to as radiation.[1]

Ionizing radiation is radiation with enough energy to remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized. This energy is released in the form of subatomic particles (alpha and beta) or waves (gamma and x rays). [2]

Primary nuclear power process: uranium fuel > nuclear fission > energy and radioisotopes.[3]

Products of nuclear fission include radioactive iodine 131, cesium 137, strontium 90, tritium, uranium and plutonium.[4]

Radioactive wastes such as uranium mill tailings, spent reactor fuel and other radioactive wastes can remain radioactive and dangerous to human health for thousands of years. [5]

Waste in spent fuel pools at reactor sites is radioactive.[6]

How does radioactive material get into the air, soil and water causing contamination?

Nuclear power plants cannot operate without regular, deliberate releases of radioactive water and gasses. The releases from the reactor building are needed to control the pressure, temperature and humidity and to keep radioactivity from exceeding government limits for workers.[7]

Radioactive material is emitted as a result of:

- Routine releases (venting)
- Design faults
- Planned maintenance (shutdowns)
- Accidents ("events")
- Equipment failure
- Operator error
- Maintenance inadequacies

Levels can range from routine releases to minor spills to core meltdowns.

What is "spent fuel" and where is it stored?

Spent fuel is highly radioactive fuel assemblies removed from the reactor core.

Spent fuel is stored on-site in the United States-
every nuclear plant is a high level radioactive waste dump

After their removal from the reactor core spent fuel is stored <u>primarily</u> in one of two ways:

In *pressurized water reactors* the spent fuel is placed in 40/45 foot water-filled concrete pits adjacent to the reactor containment structures (e.g. Seabrook).

In *boiling water reactors* the spent fuel pools are located above ground in the building surrounding the primary reactor containment structure (e.g. Fukushima Daiichi).[8]

Water storage is required as spent fuel rods continue to emit considerable amounts of both heat and radiation for many years.[9]

What is the potential risk of spent fuel?

Without cooling, the fuel pool water will heat up and boil. If the water boils or drains away, the spent fuel assemblies will overheat and either melt or catch on fire.

<u>Spent fuel pools contain more highly radioactive fuel than the reactor cores</u>.[10] On a limited basis when the spent fuel pools are full and have cooled sufficiently , the spent fuel could be moved to concrete casks. Spent fuel is therefore a softer target than the reactor core.

Risk factors to spent fuel include loss of water, loss of electricity, fire, dense packing, natural disasters (tornadoes, hurricanes, earthquakes, ice storms, drought, etc.) human error and terrorism.

What is dry cask storage? Is it safer? How often is it used?

Dry casks typically consist of a sealed metal cylinder containing the spent fuel enclosed within a metal or concrete outer shell. Casks are stored vertically or horizontally on concrete pads.[11] The Nuclear Regulatory Commission (NRC) reviews the designs for spent fuel dry storage systems.[12]

Cask storage is generally considered safer than fuel pools.

Fuel must be cooled for at least 5 years (and closer to 10 years for plants that use a higher uranium mix) before the spent fuel rods can be loaded into casks.[13]

Per the Nuclear Regulatory Commission (NRC) many reactor spent fuel pools are reaching capacity.[14]

At many reactors, when the number of spent fuel assemblies have reached pool capacity the NRC still does not require the industry to move them out of the pools. Post 9/11, it was determined that in a pool fire event or with the loss of power and subsequent loss of coolant from an accident or intentional sabotage the closer the assemblies were racked, the less time operators had to prevent the spent fuel rods from exposure. [15]

Spent fuel is a worldwide problem- tens of thousands of tons exist. According to the Nuclear Energy Institute, there were 65,193 metric tons of spent fuel stored at nuclear sites across the United States in December 2010. Of this amount, 49,620 metric tons resided in spent fuel pools while 15,573 metric tons had been transferred to dry cask storage. By comparison, the reactor core of a large nuclear power reactor contains around 200 metric tons of irradiated fuel.[16] The U.S. nuclear industry generates 2000-2300 metric tons of used fuel per year. [17]

Plants argue that cask storage is more expensive, takes more downtime to accomplish and is therefore too expensive for their ratepayers.

Health effects of radiation

In general, what is the health risk of radiation?

Exposure to ionizing radiation causes damage to living tissue and high doses can result in mutation, cancer, radiation sickness, and death.[18]

Effects on human health vary by an individual's age and health as well as by the type of radionuclide, level of exposure, and duration of exposure.[19]

Children and the unborn are especially susceptible because of their rapid cell division during growth.[20]

Cancers linked to ionizing radiation include most blood cancers (leukemia, lymphoma) lung cancer and many solid tumors of various organs. Birth defects can include congenital malformations, spinal defects, kidney and liver damage.[21]

What level of exposure to radiation is safe?

Experts disagree on risk levels.

A "permissible" or "acceptable" level does not mean a safe level.

Once released, radionuclides end up in drinking water, vegetables, grass, meat, etc. The higher the animal eats on the food chain the higher the concentration of radionuclides. This is bioaccumulation.[22]

Many experts do agree that minimizing exposure is important, especially for children and adults with weakened immune systems.[23]

What does it mean when the media reports that radiation releases will have "no impact on health"?

Misinformation by the reporter and/or the information source.

What can be done if someone is exposed or at risk of exposure?

The first thing to do is to try to minimize exposure to contamination by removing clothes and shoes, and washing the skin with soap and water.[24]

Seek immediate medical attention.

Evacuate the contaminated area (in some cases citizens may be asked to shelter in place).

Ensure that people do not eat foods or liquids (milk, water, etc.) contaminated by radiation.

Does potassium iodide or "KI" protect humans from the dangers of exposure to radiation?

Radioactive iodine 131 generated in nuclear power plants is a major health concern.[25]

Radioactive iodine is quickly absorbed and concentrated by the thyroid.[26]

Potassium Iodide (KI) if taken within a few hours before or after exposure to inhaled or ingested radioiodine saturates the thyroid gland with non-radioactive iodine and blocks the uptake of the radioactive iodine. It is an important agent for protection against thyroid-related health effects.[27]

Availability of KI? Check with your local Board of Health .

Your physician and pediatrician should be contacted for appropriate dosages.

CAUTION: KI does not protect people from other long-lived radioactive isotopes.

Health Risks from Exposure to Low Levels of Ionizing Radiation- Beir VII Phase 2 Report

Among the committee's findings:

Current scientific evidence is consistent with the hypothesis that there is a linear dose-response relationship between exposure to ionizing radiation and the development of radiation-induced solid cancers in humans.[28]

The harmfulness of ionizing radiation is a function of dose.[29]

Studies of cancer in children following exposure in utero or in early life indicate that radiation-induced cancers can occur at low doses.[30]

Nuclear reactor security

Security focuses on the intentional misuse of nuclear or other radioactive materials to cause harm-mainly external threats to materials or facilities.[31]

How are nuclear power plants protected?

The primary elements of protection consist of:

Physical barriers and illuminated detection zones
Security forces
Surveillance patrols
Guard towers
Cybersecurity programs[32]

What are the Design Basis Threats (DBT)?

The DBT's provide a general description of the attributes of potential adversaries who might attempt to commit radiological sabotage or theft or diversion against which a licensee's (nuclear plant's) physical protection systems must defend with high assurance.[33]

A revised Design Basis Threat Rule was issued in March 2007.[34] All existing nuclear reactors, fuel cycle facilities and future plants must adhere to this rule.

Are nuclear reactors secure from terrorists or others?

Entities managing the 104 nuclear reactors in the United States are expected to inform the NRC by June 10, 2011 of what preparations, systems, and specialists they have ready to employ following a potential strike by extremists. The federal government is seeking to confirm that atomic (nuclear) plant operators can handle an event causing an extended electricity failure or significant amounts of structural harm at a facility, and to assess the potential need to revise NRC rules. Site managers must follow up their initial reports with additional detail by July 11, 2011. Washington started undertaking reforms to its atomic facility policies in light of the Japanese nuclear crises.[35]

The NRC conducts some force-on-force tests at operating nuclear power plants.[36]

In a force-on-force test, mock intruders challenge physical protection (i.e. intrusion, detection systems, locked doors, etc.) as well as the security guard force. The mock intruders attempt to simulate disabling enough equipment to cause damage to the fuel in a nuclear reactor.[37]

The NRC does not use force-on-force tests to demonstrate security compliance for operating reactors during outages when dozens of temporary workers are allowed inside.[38]

The NRC does not use force-on-force tests to demonstrate security compliance for spent fuel storage at operating reactors and reactors that have been permanently shut down.[39]

For the decade from 1995 to 2005, the NRC force-on-force tests revealed serious security problems at @50% of the operating plant sites.[40]

After 9/11, the NRC removed discussion of this cornerstone from the public arena.[41]

Are nuclear reactors built to withstand natural disasters?

Presumably-yes. However, public safety risks associated with a nuclear power accident stemming from natural disasters are mistakenly presumed to be negligible.[42] Events – and combinations of events – can occur, as we have seen in Japan, that overcome design protection.

Fukushima Daiichi was hit by a cataclysmic event, however, the bottom line is that the plant lost its electricity. Other natural phenomenon including hurricanes, lightning, earthquakes, ice storms, drought, and wild fire can all contribute to increased safety risks at nuclear power plants.[43]

The International Atomic Energy Agency (IAEA) estimates that approximately 20 percent of nuclear reactors around the world are currently operating in areas of significant seismic activity.[44]

All U.S. nuclear power plants receive their electrical power for safety reactor systems primarily from the offsite electrical grid system. A typical nuclear power station will be connected to the electric grid through three or more transmission lines. Should these power lines go down or a regional electrical grid collapse occur, onsite emergency generators (diesel, gas turbines or in a few cases hydroelectric dams) are designed to automatically start with manual backup capability. Emergency power is then prioritized to a limited number of safety-class circuits.[45]

"Station Blackout" is defined as the simultaneous loss of all off-site alternating current and on-site emergency backup systems. Over 50% of all postulated accidents leading to a core melt accident begin with a station blackout according to NRC studies. For example, a natural disaster that disables the incoming power lines to a nuclear power station coupled with the failure of on-site emergency generators (i.e. fouled diesel fuel) can result in the depletion of the emergency battery supply system after 4 hours. Without electricity the operator loses instrumentation and control power leading to an inability to cool the reactor core.[46]

In Massachusetts , flooding continues to be the most common and costly type of emergency annually. Flooding is most frequently caused by persistent or heavy rainfall, but it can also be caused by naturally melting snow and ice. Both Seabrook Station over the line in New Hampshire and Pilgrim Station in Plymouth MA are at risk from coastal flooding as both are sited on marshlands adjacent to the Atlantic Ocean. [47]

On May 14, 2011 the U.S. Army Corps of Engineers anticipated opening the Morganza Spillway on the western bank of the swollen Mississippi River to divert flood waters. Three nuclear power plants were in danger of being flooded. In addition, reports indicated that power lines from floods and the Southeast big tornado cluster had knocked out many nuke warning sirens. Local police and emergency workers were very hampered by roads cut off by the floods.[48]

Unfortunately, these naturally occurring storms have proved more frequent and more severe.

What else weakens nuclear power plant security?

Human error

Nuclear power plant safety and evacuation

Safety focuses on unintended conditions or events leading to radiological releases –mainly intrinsic problems or hazards.[49]

What are the major safety factors at nuclear plants?

Loss of electricity.

Every currently operating reactor, if deprived of power and cooling water, can melt down. Overheated fuel risks hydrogen or steam explosions that damage equipment and contaminate the whole site.[50]

U.S. plants have the same key vulnerabilities that led to the crisis in Japan. The reactors lost both their normal and back-up power supplies which are used to cool fuel rods and the reactor core. Most U.S. reactors are designed to manage station power outages (affecting primary and backup systems) for only 4 hours.[51]

Fire.

All nuclear power plants are subject to fire protection requirements mandated by the NRC in 1981.
In 2004, the NRC issued 10 CFR 50.48 (c) a voluntary approach allowing risk-informed approaches that model expected fire sizes and effects. This approach involves assessing plant design and actual fire risks in each area of a facility, taking into account such factors as the amount of combustible material, potential ignition sources and fire suppression systems. Plant owners that implement the risk-informed approach may need to install additional equipment or take other measures if the analysis calls for them. Unfortunately, only two nuclear power plants have opted for this more recent plan and forty eight reactors have informed the NRC that they intend to do so. [52]

Human error.

In large and complex interactive systems, human error can contribute substantially to system failures. At nuclear power plants, operational experience demonstrates that human error accounts for a considerable proportion of safety-related incidents.[53]

The NRC audits only about 5% of activities at nuclear plants each year.[54]

David Lochbaum, the director of the Nuclear Safety Project at the Union of Concerned Scientists (UCS) Global Security Program authored a sobering account of "The NRC and Nuclear Power Plant Safety in 2010: A Brighter Spotlight Needed".

Mr. Lochbaum noted "The Union of Concerned Scientists (UCS) has evaluated safety at nuclear power plants for nearly 40 years. We have repeatedly found that NRC enforcement of safety regulations is not timely, consistent, or effective. Our findings match those of the agency's internal assessments, as well as of independent agents such as the NRC's Office of the Inspector General, and the federal Government Accountability Office. Seldom does an internal or external evaluation conclude that a reactor incident or unsafe condition stemmed from a lack of regulations. Like UCS, these evaluators consistently find that NRC enforcement of existing regulations is inadequate."

This same report on the UCS analysis of NRC oversight of safety-related events and practices at U.S. nuclear power plants in 2010 suggests these conclusions:

> Nuclear power plants continue to experience problems with safety-related equipment and worker errors that increase the risk of damage to the reactor core-and thus harm to employees and the public.
>
> Recognized but misdiagnosed or unresolved safety problems often cause significant events at nuclear power plants, or increase their severity.
>
> When onsite NRC inspectors discover a broken device, an erroneous test result, or a maintenance activity that does not reflect procedure, they too often focus just on that problem. Every such finding should trigger an evaluation of why an owner failed to fix a problem before NRC inspectors found it.
>
> The NRC can better serve the U.S. public and plant owners by emulating the persistence shown by onsite inspectors who made good catches while eliminating the indefensible lapses that led to negative outcomes.

And finally

> Four of the 14 special inspections occurred at three plants owned by Progress Energy. While the company may simply have had an unlucky year, corporate-wide approaches to safety may have contributed to this poor performance. When conditions trigger special inspections at more than one plant with the same owner, the NRC should formally evaluate whether corporate policies and practices contributed to the shortcomings.[55]

Are first responders ready for a nuclear accident? What evacuation plans are established within 10 miles? Within 50 miles?

Do you live within 50 miles of a nuclear reactor? One third of Americans do.[i56]

Local emergency management offices are the primary contact in case of a nuclear emergency. United States' plans define two "emergency planning zones".

> -Plume Exposure EPZ-a 10 mile radius from nuclear plant where people may be harmed by radiation exposure. Note: people within a 10-mile radius are given emergency information about radiation, evacuation routes, special arrangements for handicapped, etc. via brochures, phone books, calendars and utility bills.
>
> -Ingestion Exposure EPZ-about a 50 mile radius from plant where accidentally released radioactive materials could contaminate water supplies, food crops and livestock .[57]

The crisis at Fukushima is a clear reminder that standard evacuation zones cannot protect the public from a nuclear accident. Current NRC regulations stipulate a 10 mile evacuation zone around nuclear plants.[58]

Through Massachusetts Emergency Management Agency's (MEMA's) training department, annual training is offered to all radiological responders. MEMA is responsible for overseeing the planning, training, equipment and exercises to support a radiological emergency response for the Massachusetts population within the 10-mile Emergency Planning Zones (EPZ's) around nuclear power stations.[59]

Evacuation plans are fraught with assumptions the primary one being that people will comply with directives instead of what they believe is in their own best interest.

Problems with emergency plans and evacuation include but are not limited to:

For the nuclear plant:

Lack of command and control details-who is in charge
Lack of definition of single to multiple threat scenarios
Lack of specific task and personnel assignments for single and multiple threat scenarios
Lack of regulations ensuring licensee coordination with offsite response organizations during hostile action
Lack of specific actions to protect onsite personnel during a hostile action (to ensure their ability to safely shut down the reactor and perform the licensee's emergency plan)
Lack of multiple primary notification systems that can be heard inside, outside and in vehicles.[60]

For the general public:

Obstacles caused by spontaneous EPZ evacuation
Obstacles caused by shadow evacuation
A large beach population compounding traffic problems (Seabrook NH and Plymouth MA)
The nature of the road system
The reliance on town employees to fulfill responsibilities beyond their job descriptions
Reception centers equipped and intended to operate 1-4 days.[61]

For example, the nuclear disaster in Japan has revived decades-old concerns about who would help evacuate schoolchildren if something similar happened in New Hampshire. At issue is who is responsible for getting children to evacuation shelters in an emergency. When the Seabrook nuclear plant was being built, the state initially proposed assigning that role to teachers. The teachers sued, arguing that they should not be forced to abandon their own families. A state court ruled in 1987 that the teachers cannot be required to take on a role in the emergency plan. The plan that was ultimately approved puts "school officials" in charge without specifying teachers' roles.[62]

In a May 15, 2011 Associated Press article, Dianne Dunfey, a Seabrook Middle School teacher, was quoted as saying, "Nobody knows who these people are. At the same time, parents are directed not to pick up their children at school if there is an evacuation order, and we find that discrepancy to be alarming".[63]

Current plans do not reflect the reality that children can instantly call or text their parents in an emergency which would make it difficult to stop parents from arriving at the schools to get their children.

Given that Boston is only 44 miles from Seabrook Station and only 46 miles from Pilgrim Station and given Gregory Jaczko's (Chairman of the NRC) advisory for Americans to evacuate beyond 50 miles from the Fukushima plant it would appear critical that a reassessment to extend evacuation plans from 10 miles to 50 miles be considered. This would require plans incorporating the evacuation of the greater metropolitan Boston area (an estimated population of 4.4 million people)! [64]

Radiation monitoring around nuclear power plants

Does the Seabrook plant monitor real-time and/or collect off-site data on levels of radioactivity?

Seabrook provides no real-time monitoring and limited off-site monitoring.

The Seabrook plant's monitoring of emissions is done at the stack vent or within the plant's various ventilation, waste and steam handling systems. The NRC maintains a network of thermo-luminescent dosimeters (TLD's) within a ten mile radius of Seabrook Station. TLDs are passive monitors used to measure radiation by measuring the amount of visible light emitted from a crystal when exposed to ionizing radiation. TLDs are on average read once every 90 days.[65] In addition, some ingestion sampling is done from 4.5 to 20.8 kilometers from Unit 1.[66] Direct radiation measurements are analyzed at Seabrook Station. All other radiological analyses for environmental samples are performed at a contractor laboratory.[67]

Why and how does C-10 REF monitor Seabrook?

In addition to NRC monitoring protocol, Seabrook is monitored by the C-10 Research and Education Foundation, Inc. This local, safe energy advocacy group, maintains a near real-time, 24 hour computerized monitoring network to detect and record airborne and waterborne emissions from the Seabrook reactor. In the absence of government oversight, citizens established the C-10 Radiological Monitoring Network (CRMN). CRMN, the most sophisticated real-time monitoring system available is under contract with the Massachusetts Emergency Management Agency (MEMA) to track elevated radiation levels in the six Massachusetts communities within the 10 mile emergency planning zone. CRMN has continuously monitored airborne and waterborne emissions since the plant went into operation, thus making C-10 the only citizen's environmental organization in the country with available data from the moment a nuclear power plant generated electricity.[68]

Data is logged in a text file every minute, 24 hours a day at each of the 15 monitoring sites. These files contain 1440 records of comma delimited fields including time, beta, gamma, wind speed and wind direction. The data fields are processed through a compiler and is available to MEMA and the MA Department of Public Health in real-time via a secured ftp site.[69]

Our monitoring program serves as a model for organizations across the country.

How are Pilgrim, Vermont Yankee, and other plants in the United States monitored?

The NRC requires licensees to report plant discharges and results of environmental monitoring around their plants. Monitoring plans vary. In annual reports licensees identify the amount of liquid and airborne radioactive effluents discharged from plants and the associated doses. These reports are available to the public on the NRC's web based ADAMS (Agencywide Documents Access and Management System) site.[70]

<u>Economics of nuclear power</u>

How do the costs of nuclear power compare to electrical power produced by other sources?

Any analysis as to the true costs of nuclear power must consider an "all-in" cost approach. The true cost of generating nuclear power must consider construction costs, subsidies, operating cost, waste disposal, decommissioning and opportunity costs.

The *Economist* observed in 2001 that "Nuclear power, once claimed to be too cheap to meter, is now too costly to matter". Since then it has become several-fold costlier to build. Its total cost now markedly exceeds that of other common power plants (coal, gas, big wind farms).[71] Wind, cogeneration, and end-use efficiency already provide electrical services more cheaply than central thermal power plants-whether nuclear or fossil-fuelled.[72]

According to Amory Lovins of the Rocky Mountain Institute, the public (both ratepayers and taxpayers) have provided more than $500 billion in subsidies, tax incentives and other financial support to the nuclear power industry over the course of the last 50 years. [73] $0.04-$0.06 of new subsidies plus $0.01-$0.04 of remaining old subsidies brings total federal support for nuclear plants, built by private utility companies, to $0.05-$0.10 for a kilowatt-hour worth $0.06.[74]

Cost of new <u>delivered</u> electricity per kilowatt hour:

Nuclear	$.14
Coal plant	$.09
Large gas plant	$.10
Large wind farm	$.07
Combined-cogen	$.055[75]
Solar	$22.3[76]

Is nuclear power a good investment for Wall St?

Wall Street's deep skepticism of a so-called "nuclear renaissance" is well founded given the industry's history. Completion costs on average were 200% more than projected-triple the original projected estimates. Of 253 reactor units initially ordered by U.S. electric utilities, 71 units cancelled before construction, and 50 units were abandoned during construction with tens of billions of dollars in sunk costs. Only 132 units were licensed and operated in the U.S. with 28 units now permanently closed before their 40-year license expired. Today, 104 units are operating. Cost overruns and construction delays in Finland and France signal that nothing has changed that would significantly alter industry history here in the U.S.[77]

Who would bear the cost of a nuclear accident?

A U.S. nuclear power-plant accident similar to the disaster in Japan would leave taxpayers on the hook for billions and perhaps hundreds of billions of dollars in health and economic damages. Federal law places most nuclear-accident liability on the shoulders of the taxpayers. The Price-Anderson act limits private liability for those costs to $375 million for an individual company, plus $12.6 billion from an industry liability pool, leaving taxpayers on the hook for the rest.[78]

This transfer of liability creates conditions for moral hazard-an incentive for an electric utility, in this case, to take on too much risk because the utility would not bear the full costs of a catastrophic event.[79]

What are decommissioning costs?

When a nuclear reactor stops operating, the facility must be decommissioned. This involves removing the plant from service and reducing radioactivity to a level that permits (ostensibly) other uses of the property.[80]

The Nuclear Energy Institute (NEI) estimates it costs $300-$500 million to decommission a nuclear plant.[81]

In fact, Exelon Corp. in August 2010 announced an agreement on a $1 billion, 10 year project to dismantle the shuttered Zion nuclear power plant. Used nuclear fuel (spent fuel) will remain on site indefinitely under the plan.[82] The actual costs are two to three times the industry's estimates and the contamination and security issues surrounding the spent fuel are not even considered in the contract price.

The nuclear industry collects its decommissioning funds from its ratepayers and investing in the stock market. An extended financial crisis as witnessed with Wall St.'s free fall beginning in 2008 has caused a dramatic shortfall in nuclear power plant decommissioning trust funds. [83]

As nuclear plants continue to generate waste that remains on site the loss of hope for reclamation of the land becomes an additional cost to the citizens and the planet for centuries.

Early Lessons from the Japanese Fukushima Daiichi Nuclear Plant Disaster

What are the areas of elevated risk at U.S. nuclear facilities revealed by the events at Fukushima?

The details of what went wrong at Fukushima are slowly emerging. What is known currently is that U.S. nuclear facilities do not require but need:

Better protection against extended power outages
Adequate severe accident management guidance
Safer storage of spent fuel
Upgraded guidance for spent fuel pool events
Additional regulatory requirements for de-fueled reactors
The need for spent fuel buildings to have operable backup emergency generation capacity
Procedures and training requirements for spent fuel pool loss of coolant accidents[84]
Venting mandates to mitigate hydrogen explosions[85]

Diesel Generators

The prolonged loss of external electricity coupled with the failure of the emergency backup diesel generators ultimately prevented the safe shut down of the Fukushima reactors and led to the subsequent core meltdowns, spent fuel pool damage and radiation release.[86]

NRC documents indicate that there have been recurrent prolonged malfunctions of emergency diesel generators at nuclear power plants in the U.S. In the past eight years there have been at least 69 reports of emergency diesel generator inoperability at 33 nuclear power plants. A total of 48 reactors were affected, including 19 failures lasting over two weeks and 6 that lasted longer than a month. These diesel failures leave nuclear plants with only 4-8 hours worth of secondary emergency battery-powered generation in the event of loss of off-site electricity. It is clear that the NRC has historically done little to address long-standing and serious problems associated with licensee maintenance of emergency diesel generators.[87]

Spent Fuel Pools

There has been speculation that water in Fukushima Unit 4's spent fuel pool completely boiled off and that there was a subsequent fire and may have been a hydrogen explosion –something that had never been contemplated for spent fuel pools.[88] In 2008, then NRC Commissioner and now Chairman Gregory Jaczko stated that "the most clear-cut example of an area where additional safety margins can be gained involve additional efforts to move spent fuel from pools to dry cask storage." "I believe the NRC should develop new regulations which requires spent fuel be moved to dry cask storage after it has been allowed to cool for five years." [89]

No steps have been taken by the NRC to do so.[90]

In 2006, the Massachusetts Attorney General sent the NRC a petition to amend its regulations to require Environmental Impact Statements for all nuclear power plant licensing decisions to consider vulnerabilities of spent fuel storage and sent a second petition in May of 2011 to suspend NRC's evaluation of Pilgrim's relicensing until the NRC has considered the spent fuel storage issues raised by Fukushima.[91]

The NRC has not taken either requested action.

Hydrogen Explosions

Hydrogen can be produced in several ways during a nuclear reactor accident. One scenario at Fukushima is that under extreme heat the zirconium cladding around the fuel rods reacted with water. This water-metal reaction gave off oxygen and hydrogen which is flammable. If the hydrogen is not removed, the build-up can lead to explosions.[92]

On March 15, 2011 an explosion at the Fukushima Unit 4 spent fuel pool is thought to have occurred clearly illustrating this particular spent fuel vulnerability.[93]

After the 1979 Three Mile Island accident which involved a hydrogen explosion, the NRC issued rules requiring nuclear power reactors to monitor hydrogen levels. In 1989, the NRC decided the size of the containment buildings on Mark I reactors could contain all of the hydrogen that could possibly be generated. In 2003, the NRC determined that hydrogen mitigating technologies were not needed for design basis accidents and they do not help with severe accidents. Based on this “logic” the NRC allowed plants to remove a requirement for hydrogen mitigation technologies from their Technical Specifications.[94]

In addition, the NRC has consistently made inaccurate statements that the Fukushima reactors did not have hardened vents to prevent hydrogen explosions and that such features are required at U.S. facilities.

IN FACT-under questioning by Congressman Edward J. Markey, Martin, J. Virgilio, NRC’s Deputy Executive Director for Reactor and Preparedness Program acknowledged that the regulatory requirement for the operability of these vents had been removed, that no such requirements had ever been in place for spent nuclear fuel pools, and that many such systems require electricity to operate.[95]

Clearly, the NRC must revisit their decisions and require operational hydrogen mitigation technologies for the reactor and for spent fuel containment.

Seismic Activity

In the past 60 years, since the beginning of the commercial nuclear power industry, geologists have learned more about the likelihood of earthquakes occurring throughout the country. For example, the geologic field of plate tectonics (how the plates of the Earth’s crust move against each other) only emerged in the 60’s after most nuclear plants had already been sited.[96]

Eight nuclear reactors are in the seismically active West Coast, approximately 27 are near the New Madrid seismic zone (including Illinois, Indiana, Missouri, Arkansas, Kentucky, Tennessee and Mississippi)[97] and 5 are in earthquake prone South Carolina.[98]

In 2010, the NRC used 2008 seismic risk data from the U.S. Geological Survey (USGS) and measures of the fragility of each reactor to conclude that the risks of core damage from earthquakes in the Eastern and Central States are greater than previously estimated, however, the NRC has not modified its regulations to include these findings.[99] The NRC also notes that it lacks detailed information regarding the physical vulnerability of nuclear power plants to earthquakes for about one third of U.S. reactors.[100]

In the wake of Fukushima what actions has the NRC promised?

On March 23, 2011, the NRC voted to require a multi-phase review of U.S. nuclear reactor safety in the wake of the Fukushima meltdown. A task force was established to:

> "Evaluate currently available technical and operational information from the events that have occurred at the Fukushima Daiichi nuclear complex in Japan to identify potential or preliminary near term/immediate operational or regulatory issues affecting domestic operating reactors of all designs, including their spent fuel pools, in areas such as protection against earthquake, tsunami, flooding, hurricanes, station blackout and a degraded ability to restore power; severe accident mitigation; emergency preparedness; and combustible gas control."[101]

Two additional phases were mandated that included that the task force was to develop near-term recommendations for regulatory and other changes using stakeholder input and a longer (90 day review) to include more stakeholder input and "to evaluate all technical and policy issues related to the event to identify potential research, generic issues, changes to the reactor oversight process, rulemakings and adjustments to the regulatory framework that should be conducted by the NRC".[102]

All of the NRC task force findings were to be made public.[103]

Japanese authorities on April 12, 2011 raised their assessment of the Fukushima nuclear meltdown to a Level 7 i.e. "Major Accident". According to the International Nuclear and Radiological Event Scale of the IAEA, level 7 means "a major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures."[104]

What actions has the NRC actually taken?

In stark contrast to actions taken by other countries (e.g. Germany and Japan shut down reactors and along with China halted new reactors and is acting to reassess nuclear reactor safety) the NRC approved license extensions for Vermont Yankee and the Palo Verde Nuclear units in Arizona even before it completed its promised review of U.S. nuclear safety.[105]

The NRC only allowed its inspectors 40 hours in which to perform each inspection for nuclear power plants that contain one nuclear reactor. For plants with more than one unit, only 50-60 hours were afforded.[106]

By contrast the Institute of Nuclear Power Operations (INPO) reportedly spent hundreds of hours performing their inspections.[107]

The NRC inspectors were initially told to limit their inspections to the adequacy of safety measures needed to respond to Design Basis Events (pre 9/11 and Fukushima). The inspectors would be accessing licensees' ability to withstand and respond only to events that have already been contemplated and analyzed by the NRC but not to measures implemented post 9/11 or to the events that occurred in Japan.

After several NRC inspectors complained of the scope limitation, guidance from the NRC was expanded to include post 9/11 measures. However, inspectors were told not to record any observations or findings in documents that would be made public. Inspectors were also told not to include matters that licensees had already identified; therefore INPO reports (concluded before the NRC inspections began) are not to be included in the NRC public reports.[108]

The NRC has failed to consider the impacts of multiple threats striking simultaneously. Current NRC regulations do not require them to. The Fukushima plant was struck by an earthquake, a tsunami, fires, total station blackout due to loss of offsite power, damage to emergency diesel generators, and overtaxed emergency response resources. The nuclear industry has recognized their flawed assumption. “What clearly has shown up in Japan is multiple, stacked events. We’ve not analyzed for all of those things” said Preston D. Swafford , the Tennessee valley Authority’s chief nuclear officer. [109]

Relicensing nuclear power plants

What is the expected useful life of plants?

U.S. reactors are licensed for 40 years by the NRC. Of the 104 nuclear reactors in the U.S. , 4.8% are older than 40 years, 38.5% are older than 35 years, and over half are older than 30 years.[110]

What is the basic relicensing process?

The license renewal process proceeds along two tracks-one for review of safety issues and another for environmental issues. Applicants must provide an evaluation that addresses the technical aspects of plant aging and describes the ways those effects will be managed. It must also prepare an evaluation of the potential impact on the environment if the plant operates for another 20 years. The NRC reviews the application and verifies the safety evaluations through inspections.[111]

The current relicensing process is focused entirely on identifying and managing the detrimental effects of aging and not on evaluating the plant's original design.[112]

The International Atomic Energy Agency (IAEA) outlines four elements that should be considered with any proposed plant life extension:[113]

A good safety performance record,
The capability to operate the plant safely during the proposed extension,
Sound economic assessment showing benefits from the investment,
Public confidence.

The IAEI report goes on to state that "preserving the existing generation capability is an attractive proposition in many Member States, given national strategy issues, growing demand, the limits of energy conservation and opposition to new nuclear plants".[114]

Why are nuclear power plants being relicensed 20 years before the end of their current license expiration?

The IAEA notes three key differences with nuclear power from other industrial assets:

The amount and longevity of the liability remaining after production of electricity ceases are considerably larger than for most business assets in other industries,
Ongoing operation may defer the capital expenditure required for decommissioning and waste storage,
Funds must be collected during operation to meet decommissioning obligations.[115]

In addition to the benefits of relicensing from the industry's perspective, early relicensing:

Obviates the difficult task of obtaining financing for new reactors.
Offers a less expensive alternative for the nuclear industry to reap profits from fully depreciated facilities.
Offers more limited assessment criteria than that required for an original license.
Offers the ability to grant a renewal while only a limited period of plant operation and safety are even knowable i.e. problems at nuclear reactors during their 3rd and 4th decades cannot negatively impact the relicensing process.
The premature license request cannot take into account plant maintenance, safety, climate change, environmental changes, technology and power needs 40 years down the road.[116]

The early application process takes away the opportunity for younger generations to be involved In the process.[117]

What is Ageing Management? What are critical elements of ageing management?

An overarching concern in relicensing is ageing management. Ageing management is defined as engineering, operations, and maintenance actions to control within acceptable limits ageing degradation of systems, structures and components. [118]

The IAEA TECDOC-1305 recognizes that nuclear power plants were designed and built at different times. "The original suppliers can no longer provide major components for many older plants because some manufacturers are no longer in that business, the manufacturing methods have been substantially changed, the current material choice, and specifications are significantly different to those in older components.[119]

The safe long-term operation of nuclear power plants must also address non-physical ageing issues. A large portion of the qualified workforce will retire in the next few years and it is essential to address this loss of expertise. Workforce planning is needed to ensure that the ageing of experienced personnel does not degrade plant safety and performance.[120]

Why did the NRC opt to relicense a U.S. plant identical to the Fukushima reactor?

The GE Mark I Boiling Water Reactor was recognized in 1972 as too vulnerable to containment rupture and radiation release in the event of a severe accident by Dr. Stephen Hanauer, a chief safety scientist in the Atomic Energy Commission. [121]

The NRC on March 21, 2011 granted a 20-year license extension to the Vermont Yankee Nuclear reactor, the same Mark I design as the severely damaged Fukushima reactor which is still in an extremely dangerous state in Japan.[122] Paul Gunter, the Director of Nuclear Oversight at Beyond Nuclear said, "given we have known this design is too dangerous since 1972, it is an unacceptable risk not only to still operate them but to extend their operating lives by another 20 years."[123]

What is the status of relicensing to date?[124,125]

Requested	82
Granted	66
Pending	16
Denied	0

Environmental impact of nuclear power

What are the long-term environmental impacts of nuclear power?

The requirements for the operation of nuclear power plants result in environmental impacts including air emissions, at all stages of the uranium fuel procurement process. Uranium mining mimics techniques used for coal and issues of toxic contamination of land and water resources occur. Abandoned uranium mines can continue to pose radioactive risks up to 250,000 years after closure.[126]

After five decades the nuclear industry has failed to resolve the nuclear waste issue.[127] Each plant is a radioactive waste dump and it is likely that these wastes will be stored onsite for a century or more which may preclude any future use of these contaminated lands.[128]

Civilian nuclear programs provide the materials, knowledge and technology to transition to nuclear weapons production as happened in India, Pakistan, Israel and North Korea. Nuclear expansion impedes the goals of nonproliferation and disarmament.[129]

Is nuclear power green? Renewable?

Nuclear power is not a green energy source. From the mining of uranium, transportation of materials, building and dismantling of plants and the waste storage issue green house gases are emitted.[130]

Uranium is not a renewable resource.[131]

Operating plants produce and emit radiation that poses a threat to the health and safety of the plant workers as well as the general public.

The concept of sustainable growth was spurred in the 60's by the massive amounts of waste generated during the boom period after World War II. There was little technology or public policy available to address this issue. It became clear that the long term goal should be a sustainable planet attainable through the better management of resources. Sustainable growth which requires that human activity not produce waste products that cannot be perpetually reused or recycled. All nuclear fission systems produce the compulsory by-product of radioactive waste that will endure for hundreds of thousands of years and clearly is not in keeping with this goal of the renewed Green Revolution.[132]

The uranium/nuclear fuel cycle just replaces one emission problem, greenhouse gases, with another, nuclear waste.

The consequences of a malfunction at a nuclear power plant are potentially disastrous even catastrophic. Proponents of nuclear power would argue that the number of incidences have been small, Three-Mile Island, Chernobyl and now Fukushima. This is no consolation to those affected by the so-called incidences. It does not matter whether they are caused by human error, outdated materials or a natural disaster because they still occur and cause great harm.[133]

We are only beginning to find out what actually occurred at Fukushima and what the short and long term consequences will be.

Conservation/Demand for electrical power

How can we reduce the demand for electrical power – and in turn nuclear reactor power plants?

Energy conservation refers to efforts to reduce energy consumption. Energy conservation can be achieved through increased efficient energy use and decreased energy consumption.[134]

According to a 2009 Union of Concerned Scientists (UCS) report, Climate 2030: A National Blueprint for a Clean Energy Economy, the United States will be able to meet projected consumer demand for electricity over at least the next 20 years without building any new nuclear reactors or coal-fired power plants. Consumer demand can be met by increasing use of renewable energy resources like wind and solar and by increasing energy efficiency.[135]

Cogeneration and renewable energy made 18% of the world's 2009 electricity, nuclear 13% (reversing their 2000 shares) and made over 90% of the world's additional electricity in 2008. Half of the world's new generating capacity in 2008 and 2009 was renewable. In 2010, renewable except big hydro dams won $151 billion in private investment and over 50 billion watts while nuclear received zero private investment and kept losing capacity.[136]

Conservation can be achieved through many avenues including:[137]

Funding research and technology to reduce commercial and residential building energy use

Stronger energy building codes

Advancing the development of solid-state lighting

Developing test procedures and minimum efficiency standards for residential appliances and commercial equipment

Advancing the nation's economic, environmental and energy security by adopting practices that contribute to the reduction of petroleum and nuclear consumption

Coordinating efforts to increase energy efficient building retrofits

Weatherization programs to make homes more energy efficient

Amory B. Lovins in the Rocky Mountain Institute's article "Forget Nuclear" published in April 2008 noted that "Over decades, megawatts and micropower can shoulder the entire burden of powering the economy. The Electric Power Research Institute (EPRI), the utilities think tank, has calculated the U.S. negawatt potential to be two to three times nuclear power's 19% share of the U.S. electricity market." RMI estimates that "Cogeneration in factories can make as much U.S. electricity as nuclear does, plus more in buildings, which use 69% of U.S. electricity. Windpower at acceptable U.S. sites can cost-effectively produce at least twice the nation's total electricity use, and other renewables can make even more without significant land-use, variability or other constraints. Thus just cogeneration, windpower and efficient use-all profitable-can displace nuclear's current U.S. output 14 times over. "[138]

Seabrook specifics

What type of reactor is Seabrook?

Light Water Pressurized Reactor[139]

Is it considered to be a good design?

Pressurized Water Reactors (PWR) are considered to be an improved designed over Boiling Water Reactors (BWR). The PWR relies on multiple safety systems in the event of an accident. If a generic problem arises with one of these safety systems, however, the NRC has failed to create regulations or request that the industry fix the problem. For example, PWR's are designed with emergency pumps that automatically pump water to replenish lost reactor coolant water. It was determined that debris inside the containment structure would be carried to and clog the sump pump. This defect would prevent the necessary recycling of water to the reactor core. This issue was identified in September 1996. As of September 29, 2010 about 50% of the 69 PWRs have taken steps to fully address this problem.[140]

Does Seabrook Use MOX fuel?

Per the NRC Inspector at Seabrook-"To the best of my knowledge they do not use MOX at Seabrook.[141]

How does the Seabrook plant compare to the Japanese Fukushima plant?

Fukushima Units 1-6 are Mark I BWR G-E designed Boiling Water reactors with spent fuel pools suspended above their reactor containments. Seabrook is a Westinghouse designed PWR with a G-E turbine.[142]

How is spent fuel stored at Seabrook? Is it secure?

Seabrook's spent fuel building is outside of containment in a separate nonreinforced building. According to Gordon Thompson at The Institute for Resource and Security Studies (IRSS) Seabrook's spent pool building cannot withstand an unintentional accident from an airplane crash or a natural force (i.e. earthquake) or from an intentional sabotage as in the 9/11 attack.[143]

To what extent does Seabrook use hardened cask storage?

Seabrook is using the Transnuclear, Inc. NUHOMS HD-32PTH dry cask storage system.[144] The casks are stored on an open pad on-site with no surrounding structure. There are currently six full casks on ISFSI.[145]

What does Seabrook do to protect local residents?

On-site monitoring
Sirens
Training for plant workers
Emergency-response plans for residents consist of:
Annual calendars are mailed to residents within emergency planning zone which provide evacuation route maps, reception centers, emergency bus information and information for patients in hospitals, nursing homes and those with special needs.[146]

What portion of staff at Seabrook are nuclear engineers? Does Seabrook use subcontractors?

This information has been requested from NextEra Energy Resources, Seabrook Station's owner. As of the listing date there has been no response.

What particular risks does Seabrook present?

Portions of Seabrook Station are less than 3 feet above sea level. The Seabrook reactor does not have a seawall other than a low revetment around the seaward portion of the site. [147]

Seabrook is on marshland. It is predicted that sea levels will increase by 1-3 feet by the end of the century. More recent reports on the latest ice sheet melting data may put the rise at 3-5 feet.[148]

Piping is exposed to brackish water.

Would my homeowners or health insurance cover risks posed by the plant?

No.

In addition, the Price Anderson Act limits each plants liability to $375M.[149] Experts agree that a significant incident would cost billions.

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