U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Nuclear Energy Risk Management

Friday, May 13, 2011
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Friday, May 13, 2011 at 10:00 a.m. the House Science, Space, and Technology Subcommittee on Investigations and Oversight & Subcommittee on Energy and Environment will hold a joint hearing entitled, *"Nuclear Energy Risk Management."* The Committee on Science, Space, and Technology has jurisdiction over all energy research, development, and demonstration projects and all federally owned or operated nonmilitary energy laboratories.[1] The purpose of the hearing is to examine nuclear energy safety, risk assessment, public health protection, and associated scientific and technical policy issues in the United States in light of the earthquake and tsunami in Japan.

Witnesses

- **Dr. Brian Sheron**, Director, Office of Nuclear Regulatory Research, Nuclear Regulatory Commission
- **Mr. Lake Barrett,** Principal, LBarrett Consulting, LLC
- **Dr. John Boice**, Scientific Director, International Epidemiology Institute
- **Mr. Dave Lochbaum**, Director, Nuclear Safety Project, Union of Concerned Scientists

Overview

In the United States, 104 operating nuclear reactors currently supply approximately 20 percent of U.S. electricity.[2] The majority of nuclear reactors came online throughout the 1970's and 80's, with the newest nuclear plant beginning generation in 1996. Currently, the Nuclear Regulatory Commission (NRC) is considering license applications for several new nuclear plants that industry is seeking to bring online over the coming decade. Southern Company is furthest along in this process, and is seeking a license from NRC to construct and operate two new nuclear reactors at its Vogtle site near Augusta, Georgia. These reactors would be the first in a new generation of nuclear plants in the United States.

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[1] Additionally, the Committee has jurisdiction over all environmental research and development, and the commercial application of energy technology, as well as all scientific research, development, and demonstrations and projects. In addition to its legislative jurisdiction, the Committee is also tasked with the special oversight function of reviewing and studying on a continuing basis laws, programs, and Government activities relating to nonmilitary research and development.

[2] "Nuclear Energy Quick Facts." *Nuclear Energy Institute*. 9 May 2011. <http://www.nei.org/filefolder/Nuclear_Energy_Quick_Facts.pdf>.

The U.S. nuclear industry has experienced significant advancements in reactor safety and risk mitigation since the construction of the previous reactor. Recent events have refocused attention to the need for continual attentiveness to these issues.

Review of Japan

On March 11, 2011, a magnitude 9.0 earthquake struck just off Japan's east coast. The earthquake was the fourth largest recorded in the last century.[3] Compounding the devastation of the earthquake, a massive tsunami followed shortly after the initial earthquake and struck Japan's coast with little preparation time. The earthquake and resulting tsunami generated widespread destruction throughout the Japanese islands and is estimated to have killed over 10,000 people. Aftershocks continued for weeks impeding humanitarian response efforts.

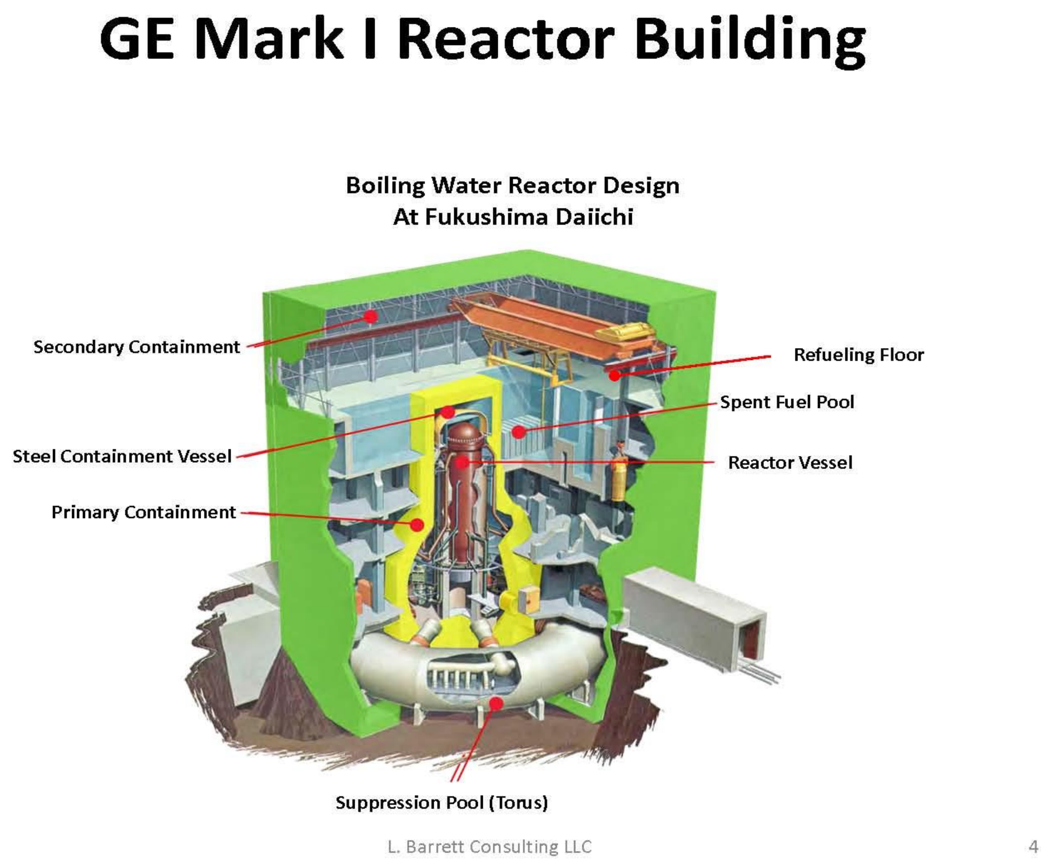
The earthquake triggered the automatic shutdown of 11 of Japan's 55 operating nuclear power plants, as designed. Within close proximity to the earthquake's epicenter stood three sites with nuclear reactors, Onagawa, Fukushima Daiichi, and Fukushima Daini. Of the six nuclear units located at the Fukushima Daiichi site, three were in operation on March 11 while the remaining three units were shut down for inspections and maintenance.

[3] "Largest Earthquakes in the World Since 1900." *U.S. Geological Survey*. 9 May 2011. <http://earthquake.usgs.gov/earthquakes/world/10_largest_world.php>.

Figure 1 – Layout of the Fukushima Daiichi Nuclear Power Plant

While further investigation is necessary to assess the specific consequences of the earthquake inside the reactors, it is believed all of the Daiichi reactors responded to the earthquake as intended. The site, cut off from the electric grid due to the earthquake, operated during this period as expected with the onsite backup diesel generators powering the cooling system for each reactor. Approximately one hour after the earthquake, an estimated 14 meter tsunami reached the Fukushima Daiichi site, overwhelmed the six meter high barrier, flooded the generators, swept away the diesel fuel tanks and eliminated all backup cooling systems located at the station (figure 1).

Figure 2 – GE Mark 1 Reactor Building



Lacking the ability to cool the reactors, Tokyo Electric Power Company (TEPCO), the owner of the Daiichi reactors, immediately began to experience severe difficulties associated with rising temperatures in the reactors. Absent primary and secondary cooling systems, TEPCO began to cool the reactor cores by pumping seawater into the reactors. Lacking the necessary information on the status of the reactor cores, water levels in the units dropped, resulting in partial exposure of fuel rods inside the reactor vessel (figure 2). As the fuel rods were exposed, the fuel rod's zirconium cladding reacted with water and generated hydrogen, which accumulated within the unit. The hydrogen buildup within the reactors ultimately led to explosions in Units 1, 2 and 3 within days of the tsunami and removed the secondary containment structures of those units.

In addition to the difficulties TEPCO faced stabilizing the cooling systems for Units 1, 2 and 3, the spent fuel pool located inside Unit 4 experienced problems. Unit 4 was undergoing maintenance at the time of the earthquake and had offloaded additional fuel rods in the spent fuel pool. While details are still not clear, in the days following the earthquake multiple fires ignited inside Unit 4 as a result of problems with the spent fuel pool. Investigation into the cause of the fires and specific spent fuel pool issues in Unit 4 are ongoing.

TEPCO continues to pump freshwater into the reactors at Units 1, 2 and 3. Further evaluation of the site's infrastructure is necessary prior to reconnecting electricity to the reactor and stabilizing the reactor cooling process. TEPCO is shooting water aimed at Unit 4's spent fuel pool to ensure the pool is adequately filled. Radiation levels surrounding the reactors remain elevated; however, they have notably decreased from spikes following the initial explosions.

Public Health Implications

Immediately following the tsunami and explosions at the Fukushima Daiichi reactors, the Japanese government ordered the evacuation of a 20 kilometer (12 mile) area surrounding the plant and directed those living within 30 kilometers (18 miles) to stay indoors. Japanese health authorities immediately began testing Japanese citizens, particularly children, for traces of radiation, but found only minimal levels of exposure. As of April 27, 2011, over 175,000 people have been screened. Radiation levels in the food supply were also evaluated and some restrictions were placed on distribution. Testing and evaluation of public health is ongoing and continue to be closely monitored. Workers at the Fukushima Daiichi plant were exposed to higher than normal radiation, though under the emergency dose limit set by the Japanese government and not enough to induce sickness. TEPCO rotates employees once the workers reach the permitted dose threshold.

As a consequence of the overheating of reactor fuel at Fukushima Daiichi Units 1, 2 and 3 and overheating within spent fuel storage areas, radiation was released into the atmosphere and environment. In the weeks following the release, traces of radiation were detected over portions of the United States. The trace amounts of radiation led to public discussion regarding the advisability of purchasing potassium iodide (KI) pills to prevent uptake of radioactive potassium and the possibility of radioactive material entering the food chain.[4] Of particular note, despite a lack of evidence suggesting human health would be impacted in the United States, U.S. Surgeon General Dr. Regina Benjamin noted in response to questioning about citizens stocking up on potassium iodide that such actions were “definitely appropriate” precautions to take.

The spread of radiation has refocused attention on the need for appropriate evacuation plans in the event of an accident or natural disaster at a nuclear facility, for appropriate plans for the return of populations to evacuated areas, the efficacy of KI distribution and long-term health implications for exposure to low-dose radiation.[5]

Evaluations of U.S. nuclear safety

The nuclear industry and governmental bodies consistently review nuclear reactor safety and risk mitigation measures in the United States. However, the 1979 accident at Three Mile Island and the attacks of September 11, 2001, in particular, spurred significant reviews of and enhancements to nuclear reactor safety.

Previous reviews provide context for current and future evaluations of nuclear energy, such as the review currently underway by the NRC in response to the incident in Japan.

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[4] For more information on radiation health implications and dose levels see Congressional Research Service Report titled, *“The Japanese Nuclear Incident: Technical Aspects.”* R41728

[5] Mason, Julie. "Fears Cause Run on Pills." *Politico* 16 Mar 2011. 9 May 2011. <http://www.politico.com/politico44/perm/0311/a_run_on_iodide_9de5fce3-9807-44b1-9721-48d1b9abab2e.html>.

Three Mile Island

On March 28, 1979, a series of mechanical and human errors led to the most significant accident in the history of the U.S. nuclear power industry. For reasons still unknown, water pumps feeding the generator shutdown. Because operators had closed valves on the secondary water system for routine maintenance, the system could not pump any water and the reactor began to overheat. A relief valve opened automatically to relieve primary system pressure; however, the valve failed to close once pressure had been released, allowing coolant water to escape. Compounding the problem was the failure of plant operators to recognize the opened valve and a misinterpretation of readings on the control panel. [6] Once operators realized the problem, serious damage had already occurred. When the core was opened four years later it was discovered that half the fuel rods had melted – a partial meltdown.[7]

In response to Three Mile Island, President Carter chartered the Kemeny Commission to investigate the accident. The Commission's recommendations covered a wide range of issues. One recommendation of note was for the nuclear power industry to establish a program that "specifies appropriate safety standards including those for management, quality assurance, and operating procedures and practices, and that conducts independent evaluations."[8] Further, "there must be a system gathering, review, and analysis of operating experience at all nuclear power plants coupled with an industry-wide international communications network to facilitate the speedy flow of this information to affected parties."[9]

As a consequence of that recommendation, the nuclear power industry established the Institute of Nuclear Power of Operations (INPO) and directed INPO to "promote the highest levels of safety and reliability – to promote excellence – in the operation of commercial nuclear power plants."[10] INPO continues to actively engage in a partnership with industry to provide valuable safety and risk mitigation expertise.

September 11, 2001

After the attacks of September 11, 2001 the NRC issued a series of orders and advisories to its license holders directing them on specific threats and security enhancements. For example, the NRC has issued orders requiring license holders to increase specific security measures, including: "increased patrols, augmented security forces and capabilities, additional security posts, installation of additional physical barriers, vehicle checks at greater stand-off distances, enhanced coordination with law enforcement and military authorities, and more restrictive site access controls." In addition, the NRC has made several changes to its Design Basis Threat (DBT), first implemented after the Three Mile Island accident in 1979. Although the DBT is not public, it outlines specific threats and characteristics of adversaries. In April 2003 and March 2006, the NRC made additions to the DBT with lessons learned from September 11. In January

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[6] "Backgrounder on the Three Mile Island Accident ." *Nuclear Regulator Commission*. <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>. Retrieved May 5, 2011.
[7] Gilinsky, Victor (March 23, 2009). "Behind the scenes of Three Mile Island". *Bulletin of the Atomic Scientists*. http://thebulletin.org/web-edition/features/behind-the-scenes-of-three-mile-island. Retrieved March 31, 2009.
[8] "*Report Of The President's Commission On The Accident At Three Mile Island*." 1979. 9 May 2011. <http://www.pddoc.com/tmi2/kemeny/utility_and_its_suppliers1.htm>.
[9] *Ibid.*
[10] "About." *Institute of Nuclear Power Operations*. Web. 9 May 2011. <http://www.inpo.info/AboutUs.htm>.

2007, the DBT was further amended to consolidate previous additions and incorporate specific threat factors outlined in the Energy Policy Act of 2005.[11]

DOE and NRC Nuclear Energy Research Programs

Both the United States Department of Energy (DOE) and the NRC fund extensive research programs across a wide variety of topics. DOE and NRC conduct significant research focused on all components of nuclear facility safety, risk analysis, and reactor design. Given recent events, the manner in which government research programs inform reactor safety and regulations are integral to ensure public health and safety.

Nuclear Regulatory Commission

The Office of Nuclear Regulatory Research (NRR) is NRC's primary research entity, coordinating research and informing regulatory decisions for the organization. The NRR provides all encompassing research relating to reactor safety, operational regulations, environmental radiological impact, and performance and reliability. The NRR office consists of Program Management, Policy Development and Analysis Staff; the Division of Engineering; Division of Systems Analysis; and Division of Risk Analysis. The primary responsibility of NRR is to provide "leadership and plan, recommend, manage, and implement programs of nuclear regulatory research and interface with all NRC Offices and the Commission on research issues."[12]

Funding Levels (In Millions)

Major Programs	FY 2010 Enacted	FY 2012 Request
Operating Reactors-Research	72.7	70.4
New Reactors-Research	23.2	13.7
Nuclear Reactor Safety Research Subtotal	**95.9**	**84.1**
Fuel Facilities-Research	0.3	0.3
Nuclear Materials Users-Research	1.2	1.4
Spent Fuel Storage and Transportation-Research	1.3	5.9
Decommissioning and Low-Level Waste-Research	1.5	0.8
High-Level Waste Repository-Research	0.0	0.0
Nuclear Materials and Waste Safety Subtotal	**4.3**	**8.4**
Total	**100.2**	**92.5**

[11] "NRC's Response to the 9/11/01 Events ." *Nuclear Regulator Commission*. 25 Apr 2011. <http://www.nrc.gov/security/faq-911.html>.

[12] All NRR and Division responsibilities are summarized from: United States. *Office of Nuclear Material Safety and Safeguards*. , 20 Apr 2011. Web. 9 May 2011. <http://nrc.gov/about-nrc/organization/nmssfuncdesc.html>.

Among NRR's tasks, the Office:

- Recommends regulatory actions to resolve ongoing and potential safety issues for nuclear power plants and other facilities regulated by the NRC;
- Conducts research to reduce uncertainties in areas of potentially high safety or security risk or significance;
- Develops the technical basis for risk-informed, performance-based regulations in all areas regulated by the NRC;
- Leads the agency's initiative for cooperative research with DOE and other Federal agencies, the domestic nuclear industry, U.S. universities, and international partners;
- Maintains technical capability to develop information for resolution of nuclear safety and security issues and provides technical support and consultation to the Program Offices in the specialized disciplines involved in these issues and;
- Collects and analyzes operational data; assesses trends in performance from this data; evaluates operating experience to provide insights into and improve the understanding of the risk significance of events, precursors and trends; and produces and disseminates periodic performance indicator and Accident Sequence Precursor (ASP) Reports.[13]

The various divisions provide valuable, informative research relating to reactor safety and risk mitigation. For example, the Division of Systems Analysis conducts research to quantify margins, reduce unnecessary burden, and reduce uncertainties for areas of potentially high risk or safety significance, supports identification of accident phenomena and assessment of anticipated safety issues in new and advanced reactors, and develops technical bases for dose limits in regulations. The Division of Risk Analysis develops, recommends, plans, and manages research programs relating to probabilistic risk assessments (PRA); develops and uses PRA-based methodologies, models, and analysis techniques, as well as other risk assessment techniques to determine overall risk; and supports agency efforts to use risk information in all aspects of regulatory decision making.

Department of Energy – Office of Nuclear Energy

The primary mission of the DOE Office of Nuclear Energy (NE) is to "advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration as appropriate."[14] The Fiscal Year (FY) 2011 continuing resolution provided $737 million for the Office of Nuclear Energy.

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[13] *Ibid*

[14] "Mission Statement." *U.S. Department of Energy*. 9 May 2011. <http://nuclear.energy.gov/neMission.html>.

Funding Levels (In Millions)

Major Programs	FY 2010 Enacted	FY 2012 Request
Reactor Concepts RD&D*	169.0	125.0
Generation IV Nuclear Energy Systems	212.9	0.0
Fuel Cycle R&D	131.9	155.0
LWR SMR Licensing Technical Support	0.0	67.0
Nuclear Energy Enabling Technologies	0.0	97.4
NE TOTAL	**870.0**	**852.0**

*FY10 Reactor Concepts RD&D was directed to Next Generation Nuclear Plant

Unlike the NRC, NE's research, development, and deployment programs are not consolidated within one office, but rather undertaken throughout all of NE's program offices. Safety and risk mitigation activities span fuel cycle research, advanced reactor research, and light water reactor sustainability research. For example, future reactor designs have passive cooling systems to cool nuclear reactor cores even in the absence of electricity. The Westinghouse AP1000 reactor design, currently under consideration for licensing by the NRC, has a passive cooling system and Small Modular Reactors also incorporate the technology.

Idaho National Laboratory (INL) is DOE's lead nuclear energy research and development facility. Primary NE tasks undertaken at INL include nuclear safety analysis, irradiation services, nuclear operations, management of spent nuclear fuel, and biocorrosion of fuels.[15] These efforts are carried out through funding from the various NE research programs. Located at INL are a number of facilities providing world class research capabilities for DOE, such as the Advanced Test Reactor Complex which is also a DOE National Scientific User Facility. Significant additional NE R&D is carried out at other Federal facilities, such as Oak Ridge National Laboratory, Argonne National Laboratory, Los Alamos National Laboratory, and Savannah River Site.

DOE's Office of Health, Safety and Security includes the Risk Assessment Technical Experts Working Group to assist DOE with the use of "quantitative risk assessment in nuclear safety related activities." These activities "help DOE ensure that risk assessments supporting nuclear

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[15] "Nuclear Energy." *Idaho National Laboratory*. 9 May 2011. <https://inlportal.inl.gov/portal/server.pt/community/nuclear_energy/277>.

safety decisions are conducted in a consistent manner, or appropriate quality, properly tailored to the needs of the decisions they are intended to support and documented."[16]

The Modeling and Simulation Energy Innovation Hub, located at Oak Ridge National Laboratory, will create a Virtual Reactor (VR) to model and simulate a nuclear reactor. The VR aims to enhance the scientific understanding of fission and reduce uncertainties associated with safety and risk. The capabilities can be used to assess and improve safety of existing reactors.[17]

Need for future reactor safety research, risk assessment, and accident mitigation

The incident at the Fukushima Daiichi reactors has highlighted the need for continual examination of safety and risk assessment in the United States. Policies and priorities undergoing heightened assessment include:

- *Spent fuel management*. What is the best and most secure method of storing spent nuclear fuel? In a spent fuel pool or dry cask storage? In a single centralized storage facility, such as the proposed, but now cancelled Yucca Mountain repository, or onsite at individual reactor locations, including at sites containing decommissioned reactors?

- *Risk assessment modeling and risk mitigation.* How can risk uncertainty be reduced to the greatest degree and incorporated into risk mitigation measures? What are the necessary inputs to produce the most realistic risk assessment models?

- *Reactor design.* What design features may warrant incorporation into the new reactors to make nuclear reactors inherently more safe and resilient to natural disasters? Do different reactor technologies offer additional safety and risk mitigation benefits?

- *Emergency planning.* Are current Emergency Planning Zones adequate? Are the lines of communication between stakeholders clear and proper? Are additional steps to ensure public health safety necessary?

- *Response.* How can response capabilities be improved in the event of a disaster? What R&D is needed in this area?

[16] "Risk Assessment Technical Experts Working Group." *U.S. Department of Energy, Office of Health, Safety and Security*. 9 May 2011. <http://www.hss.energy.gov/nuclearsafety/ns/rawg/>.
[17] "Advanced Modeling and Simulation." *U.S. Department of Energy, Office of Nuclear Energy*. 9 May 2011. <http://www.ne.doe.gov/AdvModelingSimulation/casl.html>.