U.S. Nuclear Policy Post Fukushima Event

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July 25, 2012
Renewed Interest in Nuclear Energy – Potential New Builds
President Obama’s Support For Nuclear Energy

“We can build the next-generation nuclear reactors that are smaller and safer and cleaner and cheaper.”

Ohio State University-March 22, 2012

“With rising oil prices and a warming climate, nuclear energy will only become more important. That’s why, in the United States, we’ve restarted our nuclear industry as part of a comprehensive strategy to develop every energy source.”

Nuclear Security Summit-March 26, 2012
Fukushima Dai-ichi – Responses

- President Obama asked the NRC “to do a comprehensive review of the safety of our domestic nuclear plants in light of the natural disaster that unfolded in Japan”

- Secretary Chu stated that “the Administration is committed to learning from Japan’s experience as we work to continue to strengthen America’s nuclear industry”

- Marvin S. Fertel, President & CEO Nuclear Energy Institute “The industry’s highest priority is the safe operation of the 104 reactors in 31 states and we will incorporate lessons learned from this accident at American nuclear energy facilities”
NRC Response to Fukushima

Nuclear Regulatory Commission (NRC) established a “Near-Term Task Force” of senior NRC managers and staff to determine if regulatory actions were needed to improve safety at U.S. nuclear power plants.

- **Immediate Conclusions**
  - Event sequence similar to Fukushima Dai-Ichi unlikely to occur in U.S.
  - Existing mitigation measures at U.S. plants could reduce likelihood of core damage and radiological releases
  - Based on these, there is no imminent risk from continued operations and licensing activities

- **Enhancements to Safety are Warranted**
  - Made specific recommendations regarding potential safety enhancements
Tier 1 Recommendations: Immediate Actions

Orders to Licensees
- Reliable hardened vents for Mark I and Mark II containment designs
- Mitigation Strategies for Beyond Design Basis Events
- Spent Fuel Instrumentation

Requests For More Information
- Seismic / Flooding Hazard Reevaluations
- Seismic / Flooding Plant Walkdowns
- Enhanced Emergency Preparedness Staffing and Communication

Regulatory Rulemaking
- Station Blackout Rulemaking
- Integration of Emergency Procedures
Implementation Schedule

Orders
- Operating reactors must complete implementation by 2 refueling cycles following licensee's implementation plan or by 12/31/2016
- COL holders must complete implementation prior to initial fuel load
- CP holders must complete implementation prior to receipt of operating license

Seismic/Flooding Reevaluations for operating reactors and CP holders
- Seismic hazards evaluations due September 9, 2013 for Central and Eastern US and March 9, 2015 for Western US
- Flooding hazards evaluations due between March 9, 2013 and March 9, 2015 based on prioritization (highest risk first)

Seismic/Flooding Walkdowns for operating reactors
- Results of walkdowns must be provided to NRC about May 2013 (180 days after NRC endorsement of procedure expected November 2012)

EP Staffing & Communication for operating reactors, COL and CP holders
- Licensee responses on communication and staffing issues were due June 9, 2012
- Licensee responses on staffing due by October 31, 2012

Rulemaking
- Station Blackout: Rulemaking will be complete between Dec 2013 and June 2014
- Integration of Emergency Procedures: Rulemaking will be complete by 2016
Industry is moving forward with its “FLEX Approach”

- Locate portable, quickly deployable equipment in diverse locations around the plant site and just off-site to provide water injection, power supply, and monitoring capabilities.

- Have a pre-set strategy with operators of the plants and emergency responders trained to implement strategy and all response/mitigations measures.

- These would provide additional time to respond to and mitigate emergency events and “buy time” for additional support equipment and personnel to get to the station.

- FLEX would include programmatic controls (maintenance and testing of the equipment, and personnel testing) to ensure the program is functional when called upon to do so.
Snap Shot of DOE Analysis in the Weeks Following the Accident

- Collection of daily status data and events
- Isotopic analysis of releases
- H2 production and explosions in reactor buildings
- N2 inerting options and processes
- Gas inventory calculations
- Potential for further H2 production and explosions
- Structural analysis of RPV after pressure spikes
- Core damage and fuel condition
- Sensor data analysis
- Water level calculations
- Corrosion in sea water solutions
- Drywell filling options and water level tracking
- Stabilization criteria
- Severe accident analysis and management
- Criticality determinations
- Decay heat calculations
- Isotope and radionuclide calculations and releases
- Spent Fuel Pool (SFP) water level analysis
- SFP hydrogen production and analysis
- SFP modeling
- Reactor building and SFP dose assessments
- Thermal analysis for SFP fill options
- Robotics tools for stabilization
- Shielding advice for on-site equipment
- Bioaccumulation for water releases
The MELCOR system level severe accident code is used by regulators in more than 27 countries, including the US and Japan.

Fukushima accident provided real data to assess the validity of severe accident codes.

Objectives of Study
- Collect, verify, and document data on the accidents
- Reconstruct the accidents and their progression using MELCOR
- Validate the models and analyses

Participants were Sandia National Laboratories, Idaho National Laboratory and Oak Ridge National Laboratory.
Key data and technical consultations for this effort were provided by Japan which has been doing its own MELCOR and other severe accident code analyses.

Preliminary results are encouraging in terms of capturing the essential accident signatures/trends, but there are significant uncertainties which can have a significant impact on final predicted damage states.

New information on and understanding of the accident will emerge that could lead to improved code analyses and greater confidence in the code predictive capabilities.

The OECD/NEA has recently initiated a Fukushima analysis and benchmarking project which the US strongly supports.
The primary mission of NE is to advance nuclear power as a resource capable of making major contributions in meeting the Nation’s energy supply, environmental, and energy security needs by resolving technical, cost, safety, security and regulatory issues, through research, development, and demonstration (RD&D).

NE also designs and produces nuclear energy systems to support NASA space exploration missions.
Office of Nuclear Energy
Roadmap R&D Objectives

1. Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors
2. Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration’s energy security and climate change goals
3. Develop sustainable nuclear fuel cycles
4. Develop capabilities to reduce the risks of nuclear proliferation and terrorism
Blue Ribbon Commission Recommendations


2. A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.

3. Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.

4. Prompt efforts to develop one or more geologic disposal facilities.

5. Prompt efforts to develop one or more consolidated storage facilities.

6. Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.

7. Support for continued U.S. innovation in nuclear energy technology and for workforce development.

8. Active U.S. leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.
The Department recognizes that the BRC Report represents “a critical step toward finding a sustainable approach to disposing used nuclear fuel and nuclear waste.”

The Department acknowledges that “the specifics of a new strategy for managing our nation’s used nuclear fuel will need to be addressed in partnership with Congress.”

The Department “will work in parallel to begin implementing the new strategy” by taking sensible steps toward the implementation of near-term recommendations.
### FY 2012-2013 Budget Summary

**U.S. Department of Energy**

**Nuclear Energy**

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Use of Prior Year Balances/Reprogramming

**Total, Office of Nuclear Energy**

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Vision - Enable existing nuclear power plants to safely operate beyond current license periods (beyond 60 years)

Program Goals:
- Develop fundamental scientific basis to allow long-term operation of existing LWRs
- Develop technical and operational improvements that contribute to long-term economic viability

Scope
- Materials Aging and Degradation
- Risk-Informed Safety Margin Characterization
- Efficiency improvements
- Advanced Instrumentation and Controls
- Advanced Fuel Development
Goals

- Facilitate development and demonstration of advanced manufacturing and construction technologies
- Develop and demonstrate next generation advanced plant concepts and technologies

Challenges

- Financial hurdles associated with new plant construction
- Improving safety and reducing licensing risks
Growing Interest in Small Modular Reactors (SMRs)

- Global interest motivated by economic, environmental and energy security concerns
- SMRs are being designed to provide a safe, robust and flexible alternative to current nuclear power generating capacity

Potential benefits include
- Enhanced safety from simplified designs
- Reduced capital cost
- Enhanced security from below-grade siting

U.S. Utility Considerations
- Site selection: More siting flexibility than traditional nuclear plants, lower land and water usage
- Load demand: Better match to power needs, potential replacement of older coal plants, use of existing infrastructure
- Incremental growth: multiple modules, operating units can provide financing for future additional units.

U.S. Coal Plants

99% of plants > 50 years old have less than 300 MWe capacity
Goal: Accelerate licensing and commercialization of SMR technologies

- U.S.-based SMR designs (nominally 300 MWe or less per unit)
- LWR and Advanced SMR designs
- Emphasis on safety improvements from existing designs

Cost-Shared Industry Partnership Program

- Five-year program, totaling $452M (DOE contribution)
- First-of-a kind engineering, design certification application and licensing support
  - Construction costs not included
- Goal is to have SMRs deployed and putting electricity on the grid by 2022
Demonstrate high-temperature gas-cooled reactor (HTGR) technology to produce electricity and high temperature process heat

Provide process heat for industrial processes needing temperatures 700-900°C

- Collaborate with NRC to establish a licensing framework for HTGRs
- Partner with industry to commercialize HTGR technology
- Collaborate with national laboratories, universities, and international community to perform R&D to reduce technical risk

R&D focus areas:
- Fuel qualification
- Materials (High Temperature Metals and Graphite)
- Design and Safety Methods
- Licensing Support
Advanced Reactor Concepts

- **New innovative technologies**
  - GEN IV based designs
  - Deployment 20+ years

- **R&D focus**
  - Sodium Fast Reactors
  - Fluoride Salt High Temperature Reactors
  - Supercritical CO\(_2\) Brayton Cycle Advanced Energy Conversion Technology

- **Broader applications**
  - Process heat applications
  - Improved economic competitiveness
  - Transportable/mobile
  - Waste management
  - Long-lived cores
DOE recognizes the need to invest in Advanced SMR R&D
- Deployment of Advanced SMRs would follow the near-term SMR deployment path as they mature

DOE is seeking greater interaction with industry and other stakeholders on the development of its R&D program

Established a Technical Review Panel (TRP) in 2012
- Reviews advanced reactor concepts and help identify R&D needs
- TRP members include experts from industry, national labs, and academia
- Issued Request for Information (RFI) for industry to voluntarily submit information on reactor concepts
- Results of the TRP review will be used to help inform DOE’s R&D program
NEET consists of the following program elements:

1. Crosscutting Technologies
   - Reactor Materials
   - Advanced Sensors and Instrumentation
   - Proliferation and Terrorism Risk Assessment
   - Advanced Methods for Manufacturing
   - Nuclear Energy Advanced Modeling and Simulation

2. Energy Innovation HUB for Modeling & Simulation

3. National Science User Facility
Energy Innovation Hub
Delivering Products for the Future

- **Developing Virtual Reactor**
  - Software capabilities that will be used to provide better insight into current commercial nuclear fleet
  - Built in a way that allow proprietary and open source modules to interact and to be interchanged
  - Deployed on “test stands” to be evaluated by Westinghouse, EPRI and TVA

- **Creating advanced M&S capabilities**
  - Advances in HPC algorithms and methods
  - Fundamental science advances documented in peer-reviewed publications
  - Innovations that contribute to U.S. economic competitiveness

- **Educating and training highly skilled work force in use of advanced M&S**
  - Engage university students in VR development
  - Sponsor workshops and seminars for researchers and end-users
Fuel Cycle Research and Development

- **Advanced Fuels**
  - Develop accident tolerance fuel with higher burnups and improved cladding for LWRs, and TRU bearing fuel for fast reactors

- **Used Fuel Disposition**
  - Perform R&D to enable long term storage and subsequent transportation and respond to the recommendations of the Blue Ribbon Commission report.

- **Materials Protection, Accounting and Control Technology**
  - Develop technologies and analysis tools for future fuel cycles to prevent diversion or misuse

- **Fuel Resources**
  - Perform R&D on uranium extraction from seawater

- **Separations and Waste Forms**
  - Minimize reprocessing, waste generation, and potential for material diversion
  - Develop waste forms for different waste streams and disposal environments
International Cooperation

Nuclear Energy

- DOE supports technical collaborations through bilateral Action Plans, Working Groups, and the International Nuclear Energy Research Initiative

  **Bilateral:**
  - Peaceful Uses of Nuclear Energy Agreements (123 Agreements)
  - R&D Agreements
  - Science and Technology (S&T) Agreements
  - International Nuclear Energy Research Initiatives (I-NERIs) with France, Japan, South Korea, Canada, and Euratom
  - Memoranda of Understanding (MOUs)

  **Multilateral:**
  - Generation IV International Forum (GIF)
  - International Framework for Nuclear Energy Cooperation (IFNEC)
  - International Atomic Energy Agency (IAEA)
  - International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)
  - Nuclear Energy Agency (NEA)
Focusing efforts in many programs on safety and accident tolerance

Continuing programs to develop inherently safe advanced reactors

Forming new programs to look at advanced fuels and other technologies to improve accident tolerance

Working with international community to analyze the accident to improve our modeling capability and develop lessons learned
Nuclear power remains a key element of U.S. energy strategy.

DOE’s R&D is focused on the continued safe operation of the U.S. nuclear fleet and the development of new advanced technologies that improve safety and affordability.

DOE is committed to apply lessons learned from Fukushima to develop even safer nuclear plants.

Organizations such as ANS and IEEE will play key roles.