U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Overview of Nuclear Reactor Technologies Portfolio

for

FY12 NEUP IRP Pre-Solicitation Workshop

Richard Reister

Office of Light Water Reactor Technologies

May 2, 2012

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Outline

- New Nuclear Plants
- Impacts of Fukushima Accident
- Budget
- NRT Programs
- Integration of University R&D Results into Program

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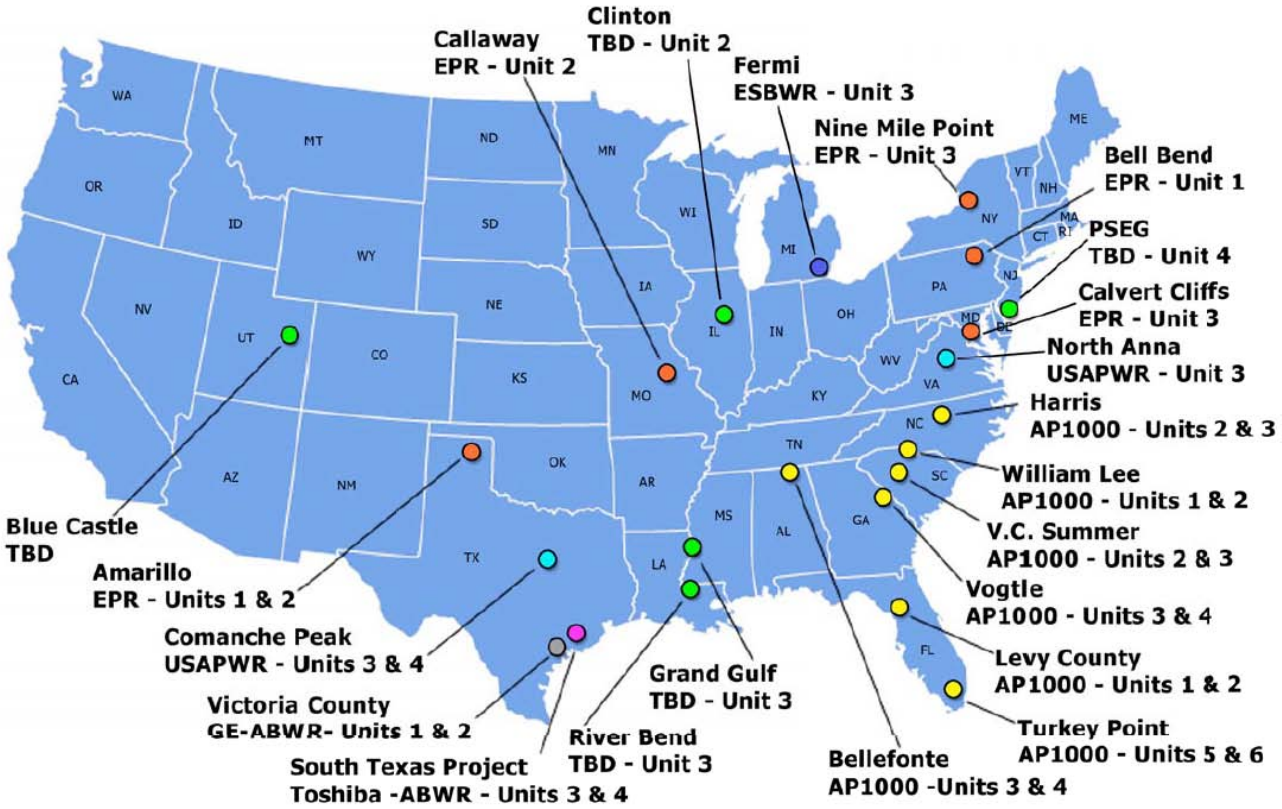
Renewed Interest in Nuclear Energy – Potential New Builds



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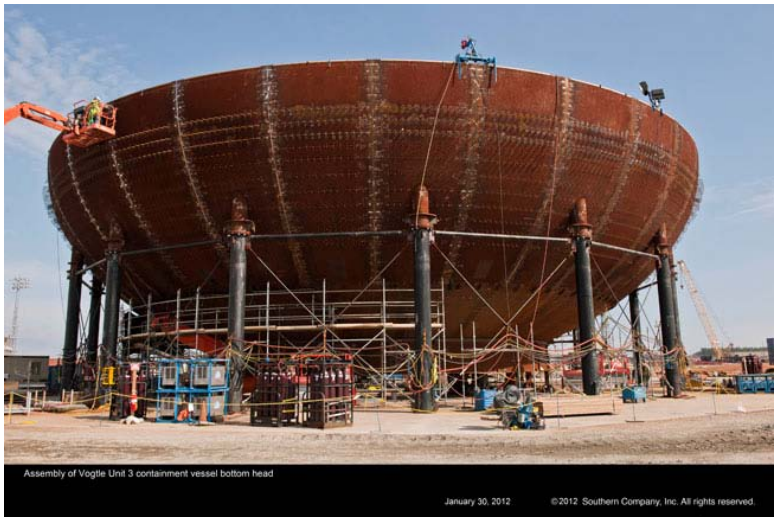
AP1000 Construction Sanmen and Vogtle

Construction of heavy lift derrick crane foundation and permanent counterweight, to be used to lift large components and modules into place for both Vogtle units 3 and 4.

March 14, 2011



Assembly of Vogtle Unit 3 containment vessel bottom head

January 30, 2012

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Fukushima Impacts on DOE/NE Research

- **Focusing efforts in many programs on safety and accident tolerance**
  - NEET, LWRS, NEAMS
- **Continuing programs to develop inherently safe advanced reactors**
  - NGNP, ARC
- **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**

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NE FY 2013 Congressional Request
Funding Summary

(Dollars in Thousands)	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Integrated University Program	0	5,000	0
SMR Licensing Technical Support	0	67,000	65,000
Reactor Concepts RD&D	164,706	114,871	73,674
Fuel Cycle R&D	182,428	186,260	175,438
Nuclear Energy Enabling Technologies	50,891	74,670	65,318
Radiological Facilities Management	51,715	69,510	51,000
International Nuclear Energy Cooperation	2,994	2,983	3,000
Idaho Facilities Management	183,604	154,097	152,000
Idaho Safeguards and Security [a]	88,752	93,350	95,000
Program Direction	86,279	91,000	90,015
Adjustments	-5,373 [b]		
Total, Nuclear Energy	**805,996**	**858,741** [c]	**770,445**

a) Requested within Nuclear Energy in FY 2013 (retains Defense function), appropriated within Other Defense Activities FY 2011 and FY 2012.
b) Includes +1,500,000 transfer from Department of State, -$552,000 use of prior year balances for reprogramming executed in FY 2011 for INL S&S, and -$6,321,000 rescission of prior year balances.
c) Reflects rescission of $3,272,000 associated with savings from the contractor pay freeze.

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President Obama's Commitment to Clean Energy

"This country needs an all-out, all-of-the-above strategy that develops every available source of American energy."

President Barack Obama
State of the Union Address
January 24, 2012

- **Keep current reactors operating by extending plant life beyond 60 years with improved performance and safety (Roadmap Objective 1)**
- **Develop new nuclear energy technology to bring nuclear electricity to marketplace (Roadmap Objective 2)**
- **Look for other non-electric opportunities to allow penetration of nuclear energy into industrial and transportation markets (Roadmap Objective 2)**

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Light Water Reactor Sustainability

- **Four LWRS research pathways to provide technical basis to extend current fleet beyond 60 years with improved performance and safety:**
  - Nuclear Materials Aging and Degradation
  - Risk-Informed Safety Margin Characterization
  - Advanced Instrumentation, Information, and Control Systems Technologies
    - Radiation resistant instrumentation under accident conditions
  - Advanced LWR Nuclear Fuel Development
    - Accident tolerant fuels

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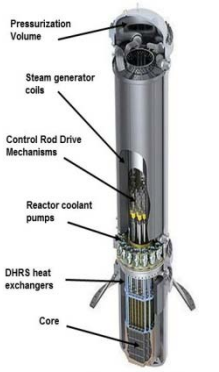
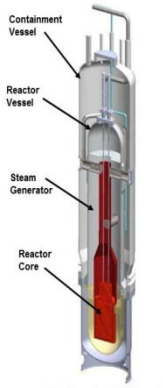
Small Modular Reactors

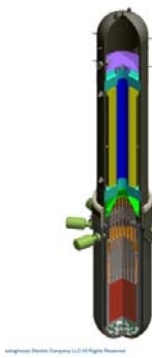
- **Near-Term LWR Designs**
  - Well understood Technology
  - Standard <5% UO_2 fuel
  - Regulatory & operating experience
  - Deployment in10 years (2020)
- **Longer-Term Designs**
  - New innovative technologies
  - Mostly non-LWR based designs
  - Deployment 20+ years
  - Broader applications
  - Process heat applications
  - Transportable/mobile
  - Long-lived cores



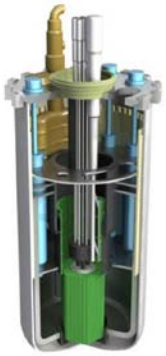
mPower (Babcock & Wilcox)
125 MWe

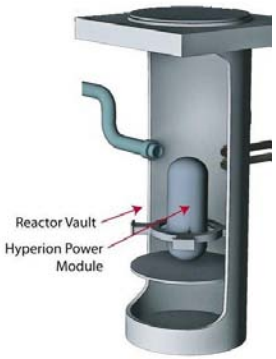


NuScale (NuScale)
45 MWe


Westinghouse
200 MWe


Holtec HI-SMUR
140 MWe


GE PRISM



Hyperion


GA MHTR

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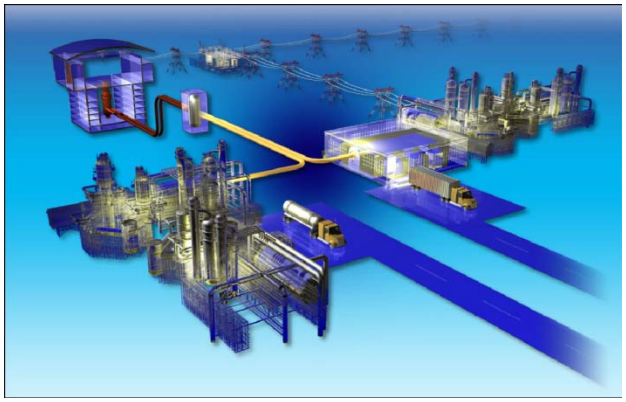
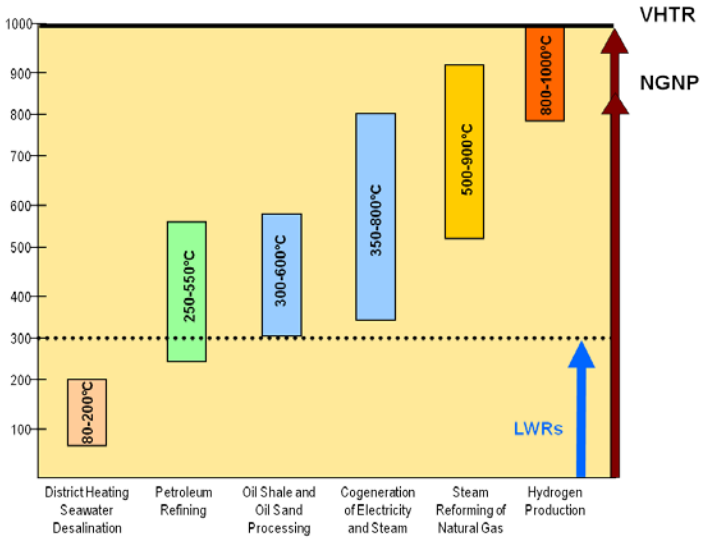
Next Generation Nuclear Plant

- **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





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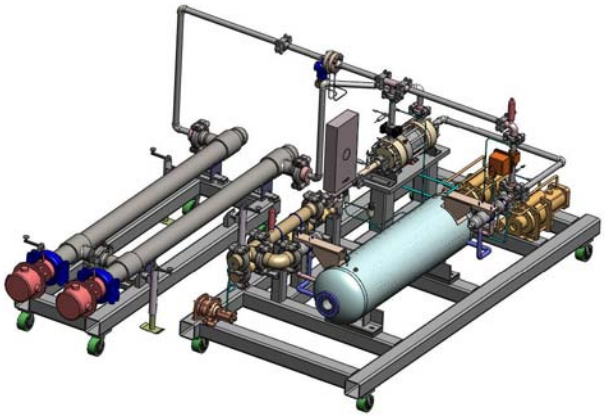
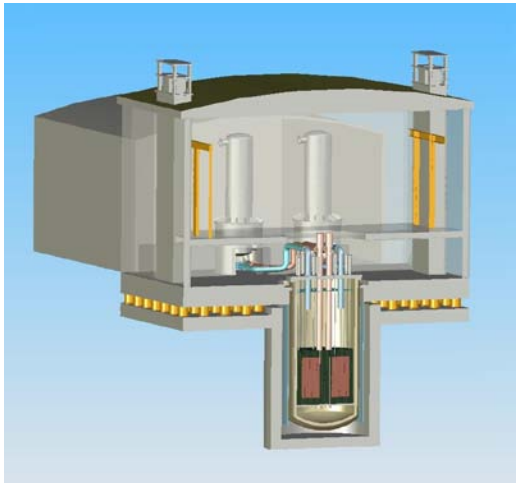
Advanced Reactor Concepts

- **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
  - Address environmental challenges





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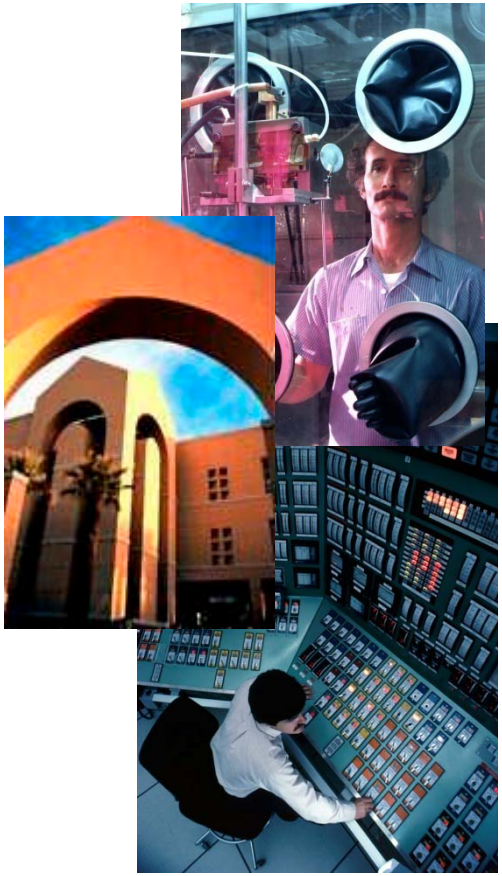
Nuclear Energy Enabling Technologies (NEET)

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
   - Advanced Modeling and Simulation
2. **Energy Innovation HUB for Modeling & Simulation**
3. **National Science User Facility**



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NEET Crosscutting Technologies

Provides support to various reactor and fuel cycle technologies:

- Reactor Materials
  New classes of alloys and materials not yet considered for reactor performance may enable transformational reactor performance.
- Advanced Sensors and Instrumentation
  Research on unique sensor and instrumentation infrastructure technology to monitor and control new advanced reactors and small modular reactor systems.
- Advanced Methods for Manufacturing
  Research on advanced manufacturing technologies that draw upon successful practices in oil, aircraft, and shipbuilding industries, as appropriate, and employ modeling and simulation capabilities.
- Proliferation and Terrorism Risk Assessment
  Develop new tools and approaches for understanding, limiting, and managing risks of proliferation and physical security for fuel cycle and reactor system options.
- Nuclear Energy Advanced Modeling and Simulation
  Develop advanced modeling and simulation tools and methods that focus on the next generation of technologies.

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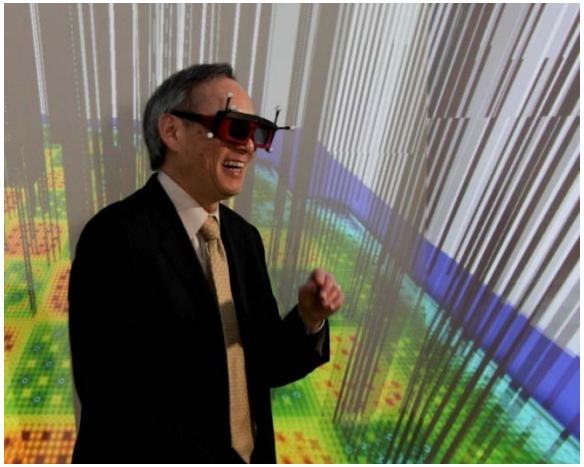
Energy Innovation Hub

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



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National Scientific User Facility (NSUF)

- **ATR-NSUF is a "prototype laboratory of the future" – a network of world-class, unique research facilities and equipment**
- **Provides universities and their partners access to facilities and personnel they would not normally have**
- **Researchers' work benefits from new techniques, equipment, experimental capabilities, and expert personnel**
- **Program offers both irradiation and post-irradiation examination services. Partner facilities include:**
  - Test Reactors at INL's ATR, ORNL's HIFR, and the reactors at MIT and NC State
  - The Advanced Photon Source beam line capabilities at the Illinois Institute of Technology
  - Post-Irradiation Examination facilities at INL's Materials and Fuels Complex and Center for Advance Energy Studies and the Universities of Wisconsin, Michigan, California-Berkeley, and Nevada-Las Vegas
- **ATR-NSUF provides funding for experiments support and laboratory services at the user facilities**

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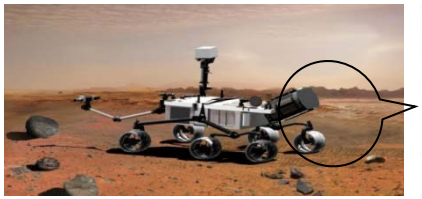
Space Nuclear Power Program

- **Multi-Mission Thermoelectric Generator (MMRTG)**
  - Fueled with Pu^{238}; 110 We
  - Used on the Mars Science Laboratory rover "Curiosity"
  - Launched Nov. 2011, Mars landing – August 2012

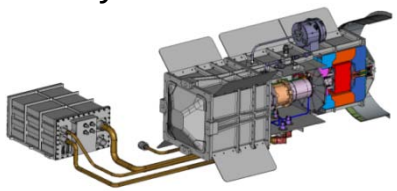


Mars Science Laboratory

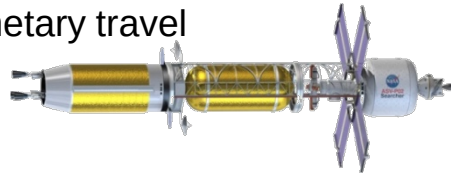
Titan Mare Explorer

Comet Hopper

- **Advanced Stirling Radioisotope Generator (ASRG)**
  - Fueled with Pu^{238}
  - Uses Stirling converter to produce about 130 We
  - Over 4x more efficient than RTGs
  - Could be used on the Discovery 12 mission



- **Nuclear Thermal Propulsion**
  - Nuclear fission reactor heats H^2 to produce thrust for inter-planetary travel



- **Fission Surface Power System**
  - 40 kWe fission reactor for use on the Moon, Mars or near earth object