U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Nuclear Energy University Programs (NEUP) Approach and Issues for Fiscal Year (FY) 2012

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U.S. Department of Energy

NEUP FY 2012 Annual Planning Workshop
Chicago, Illinois
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Innovation and Competitiveness

"This is our generation's Sputnik moment. … We'll invest in biomedical research, information technology, and especially clean energy technology -– an investment that will strengthen our security, protect our planet, and create countless new jobs for our people."

"So tonight, I challenge you to join me in setting a new goal: By 2035, 80 percent of America's electricity will come from clean energy sources. Some folks want wind and solar. Others want nuclear, clean coal and natural gas. To meet this goal, we will need them all…"

President Barack Obama

State of the Union Address

January 25, 2011

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NEUP Supports the NE Mission

The primary mission of the Office of Nuclear Energy 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.

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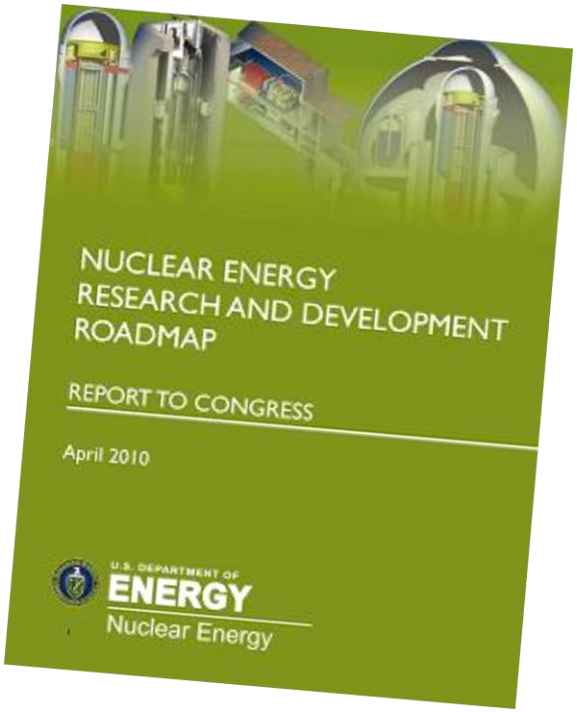
Nuclear Energy Roadmap

- **Nuclear energy objectives were developed to focus resources on national imperatives for clean energy, economic prosperity, and national security.**
- **Contribution of nuclear power to U.S. energy mix must increase significantly to meet these aggressive objectives.**
  - Internal and external studies project growth on the order of 50 to 100 GWe by 2030.



- **NE Roadmap outlines an integrated approach to meet objectives.**
- **Roadmap addresses transformation of NE programs to a more science-based approach.**

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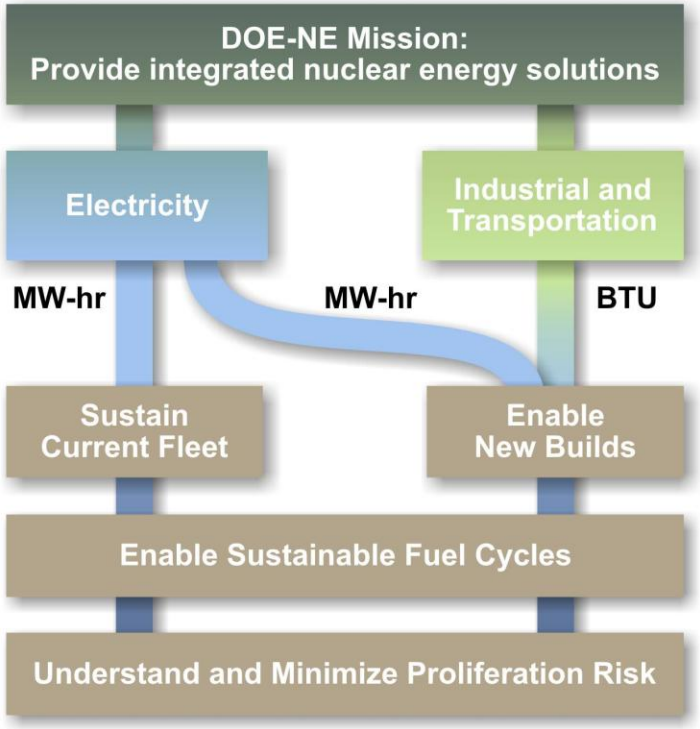
Nuclear Energy Objectives

- Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors
- Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy security and climate change goals
- Develop sustainable nuclear fuel cycles
- Understand and minimize the risks of nuclear proliferation and terrorism



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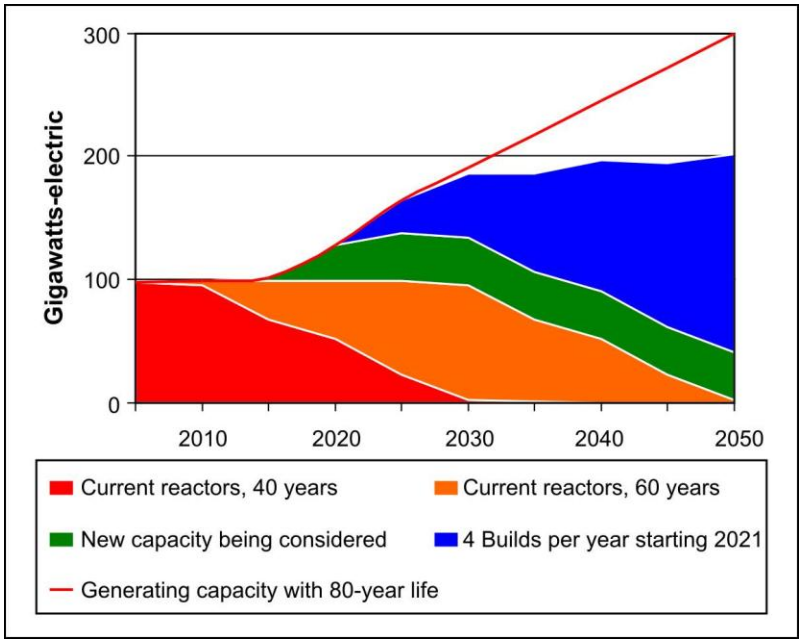
Objective 1: Life Extension

- **Goal is to extend plant life beyond 60 years with improved performance**
- **Challenges**
  - Aging and degradation of system structures and components
  - Fuel reliability and performance
  - Obsolete analog instrumentation and control technologies
  - Design and safety analysis tools based on 1980's vintage knowledge bases and computational capabilities



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Objective 2: New Builds

- **Goals**
  - Demonstrate 10 CFR Part 52 licensing framework
  - Facilitate accelerated licensing of small modular reactors
  - 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
  - Deploy small reactors to reduce up front capital costs
  - Develop plant designs that address industrial needs
  - Develop new regulatory frameworks

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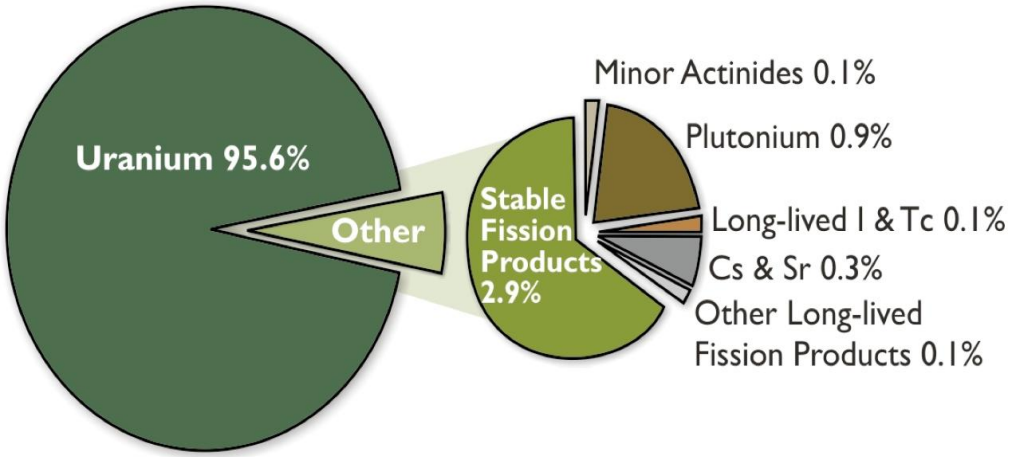
Objective 3: Sustainable Fuel Cycles

- **Goals**
  - In the near term, define and analyze fuel cycle technologies to develop options that increase the sustainability of nuclear energy
  - In the medium term, select preferred fuel cycle option for further development
  - By 2050, deploy preferred fuel cycle
- **Challenges**
  - Develop high burnup fuel and structural materials to withstand irradiation for longer periods of time
  - Develop simplified separations, waste management, and proliferation risk reduction methods
  - Develop optimized systems to maximize energy production while minimizing waste



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Objective 4: Understand and Minimize Proliferation Risk

- **Goal is limiting proliferation and security threats by protecting materials, facilities, sensitive technologies and expertise.**

- **Challenges**
  - Develop proliferation risk assessment methodologies and tools
  - Minimize potential for misuse of technology and materials
  - Develop highly reliable, remote, and unattended monitoring technologies
  - Design improved safeguards into new energy systems and fuel cycle facilities
  - Develop advanced material tracking methodologies

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FY 2010-12 Budget Table

Program	FY 2010 Approp.	FY 2011 Enacted	FY 2012 Request	FY 2012 House Mark
Research, Development, & Demonstration				
Integrated University Program	5,000	-	-	5,000
Nuclear Power 2010	101,960	-	-	-
LWR SMR Licensing Technical Support	-	-	67,000	67,000
Generation IV Nuclear Energy Systems	212,904	-	-	-
Reactor Concepts RD&D	-	168,535	125,000	136,986
Fuel Cycle Research and Development	131,938	187,616	155,010	132,000
Nuclear Energy Enabling Technologies	-	51,383	97,364	95,014
International Nuclear Energy Coop.	-	2,994	3,000	3,000
Infrastructure				
Radiological Facilities Management	71,760	51,714	64,888	49,000
Idaho Facilities Management	172,716	183,604	150,000	155,000
Idaho Sitewide S&S	83,358	77,550	98,500	93,350
Program Direction	73,000	86,279	93,133	92,000
Other (Congress. Directed Projects and Transfers)	5,300 [a]	10,650 [b]	-	-
Use of Prior Year Balances	-	-	-1,367	-1,367
Total NE:	**857,936**	**820,325**	**852,528**	**826,983**

[a] $2,800k transfer from State Department and $2,500k CDP; [b] $10,650k transfer from NNSA Weapons Activities for Idaho S&S

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Reactor Concepts Research, Development and Demonstration

Budget Summary
$ in thousands

Program Element	FY 2012 Request
Small Modular Reactor Advanced Concepts R&D	28,674
Next Generation Nuclear Plant (NGNP)	49,572
Light Water Reactor Sustainability	21,384
Advanced Reactor Concepts	21,870
SBIR/STTR	3,500
Total:	**125,000**

- **Mission**
  - Develop new and advanced reactor designs and technologies that advance the state of reactor technology to broaden applicability, improve competitiveness, contribute to our nation's energy portfolio, and address environmental challenges

- **FY 2012 Planned Accomplishments**
  - Conduct R&D on advanced SMR designs
  - Establish critical path R&D activities and work with industry to establish the business plan and approach for the long-term execution of NGNP
  - Research technologies that support safe and economical long-term operation of the existing nuclear fleet
  - Conduct R&D on Advanced Reactor Concepts

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Fuel Cycle Research and Development

Budget Summary
$ in thousands

Program Element	FY 2012 Request
Separations and Waste Forms	36,893
Advanced Fuels	40,443
Transmutation R&D	3,109
Systems Analysis & Integration	20,466
Materials Protection, Accountancy & Control Technology	7,864
Used Nuclear Fuel Disposition	37,249
Fuel Resources	4,646
SBIR/STTR	4,340
Total:	**155,010**

- **Mission**
  - Conduct science-based, goal-oriented research and development in support of developing options to the current U.S commercial fuel cycle management strategy to enable the safe, secure, economical and sustainable expansion of nuclear energy while reducing proliferation risks
- **FY 2012 Planned Accomplishments**
  - Examine three fuel cycle strategies: once-through, modified open, and full recycle
  - Apply new approaches to R&D that integrate theory, experiment, and high-performance modeling and simulation to enable the development of safe, secure and economical fuel cycle options
  - Investigate technologies that support increased utilization of fuel resources and reduce long-lived radiotoxic elements that would require disposal
  - Research the economic feasibility of extracting uranium from seawater

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Nuclear Energy Enabling Technologies

Budget Summary
$ in thousands

Program Element	FY 2012 Request
Crosscutting Technology Development	41,178
Transformative Nuclear Concepts R&D	14,580
Energy Innovation Hub for Modeling & Simulation	24,300
National Scientific User Facility	14,580
SBIR/STTR	2,726
Total:	**97,364**

- **Mission**
  - Develop crosscutting technologies that directly support and complement NE's R&D efforts and encourage transformative, "out of the box" solutions
- **FY 2012 Planned Accomplishments**
  - Evaluate innovative materials for use in high radiation/high temperature areas
  - Develop improved tools and methods for assessing proliferation risks
  - Improve reactor component manufacturing
  - Develop advanced systems to control and monitor plant materials and performance
  - Award investigator-initiated transformative nuclear technology research
  - Major release of the Virtual Reactor Code with significantly improved capabilities
  - Support and expand the NSUF partnerships
  - Deliver advanced modeling and simulation capabilities to be used in support of the reactor and fuel cycle R&D programs

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Recent Key Events/Reports

- **Announcement of NEUP FY 2011 R&D Awards**
- **Fukushima accident – March 11, 2011**
  - NRC Recommendation for Enhancing Reactor Safety in the 21st Century – The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident. July 12, 2011
- **MIT Report: The Future of the Nuclear Fuel Cycle**
- **Blue Ribbon Commission on American's Nuclear Future:**
  - Draft Report to the Secretary of Energy- July 29, 2011

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NEUP FY 2011 R&D Awards

- **Awards amounting to $39 million are being announced today for 51 projects which leverage the R&D capabilities of U.S. universities and colleges**
- **These awards are being made to 31 universities in more than 20 states**
- **"Investments in cutting-edge nuclear energy research are critical to creating clean energy jobs and building a robust new energy economy. These projects will develop the nuclear energy technologies required to advance our domestic nuclear industry and maintain global leadership in the field." – Secretary Chu**
- **The projects will focus on:**
  - Fuel Cycle Research and Development
  - Reactor concepts Research, Development and Demonstration
  - Nuclear Energy Advanced Modeling and Simulation
  - Transformative Research

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Mission Overview - Fukushima Impacts the NE Focus for 2012

Before March 11, 2011

After March 11, 2011

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Fukushima Dai-ichi - Responses

- President Obama asked the Nuclear Regulatory Commission *"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 the104 reactors in 31 states and we will incorporate lessons learned from this accident at American nuclear energy facilities"*
- *DOE's Office of Nuclear Energy is reviewing its research portfolio to better understand how it can best support overall US Govt response*

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DOE/NE Research Impacts: Post - Fukushima

- **Reducing the need for Operator Actions in Accident Response enhances overall safety**
  - Passive Systems enhance safety
    - AP1000, ESBWR, SMRs, HTGRs
  - Better understanding of dry cask storage systems.
- **Re-engineering barriers can reduce complications**
  - SiC cladding
  - Enhanced fuel properties
- **Re-evaluation of potential natural phenomena**
  - Re-evaluation of U.S. seismic criteria
- **Targeted use of Modeling and Simulation**
  - Improved modeling of operating reactors
- **Enlistment of the University Community**.

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Improved Safety of Dry Used Nuclear Fuel (UNF) in Storage Research is Timely

<u>Integrated Research Project</u> (IRP) – "UNF Accelerated Aging in Storage"

- IRP up to $1.5 million/year for 3 years to be awarded in FY 2011
- Focus on R&D of accelerated aging techniques to better understand long-term degradation mechanisms
- Present regulatory basis for dry cask storage is 60 years but better under-standing of limiting mechanisms may enable significantly increased duration.
- IRP to focus on long-term behavior of high burnup UNF (>45 gigawatt-days/MT). Issues include:
  - Long-term integrity of cladding, fuel assembly support brackets/spacers
  - Canister leakage
  - Hydride diffusion and embrittlement
  - Creep
  - Corrosion and stress corrosion cracking
  - Accelerated degradation due to marine environment (e.g., salty air)

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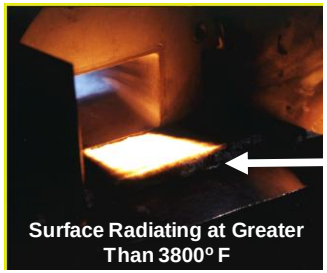
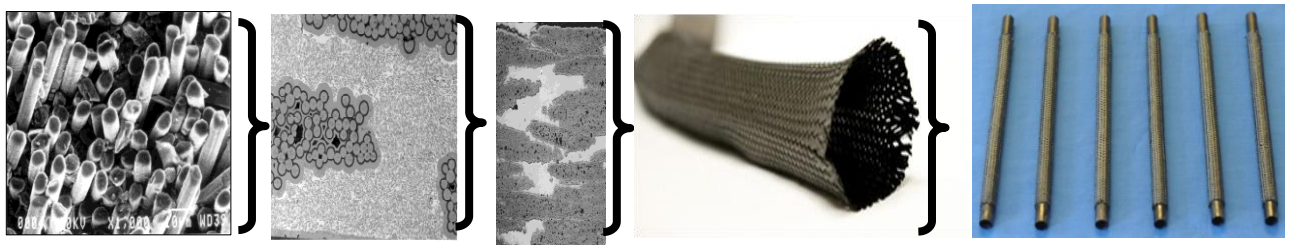
R&D Into Silicon Carbide As A Potential Nuclear Fuel Cladding

- **Mission to develop advanced materials and design concepts to demonstrate very advanced fuels in a high-risk, high-reward program to significantly improved safety margins and operating margins at commercial LWR's.**
  - *Nuclear Energy Research and Development Roadmap, 2010*
- **Apply Silicon Carbide Ceramic Matrix Composites (SiC CMC) to create nuclear fuel cladding.**
  - Strength increases with temperature, SiC disassociates at 4900°F
  - Much reduced hydrogen production, and improved LOCA performance
  - Radiation stable in radiation field
- **Preliminary fabrication and irradiation test campaigns are underway at ORNL, MIT, and INL to explore corrosion & stability**
- **Material, design and chemical issues to resolve for demonstration in 2015-2020.**
- **Funding FY 2009 $500K, FY 2010 $1980K, and FY 2011 $2854K**
- **Commercial in-kind partners**
- **7+ patents and invention disclosures**





CMC structure with increasing scale

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MIT Assessment of Uranium Resources

"There is no shortage of uranium resources that might constrain future commitments to build new nuclear plants for much of this century at least."

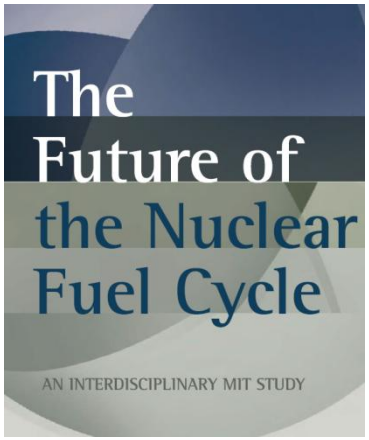
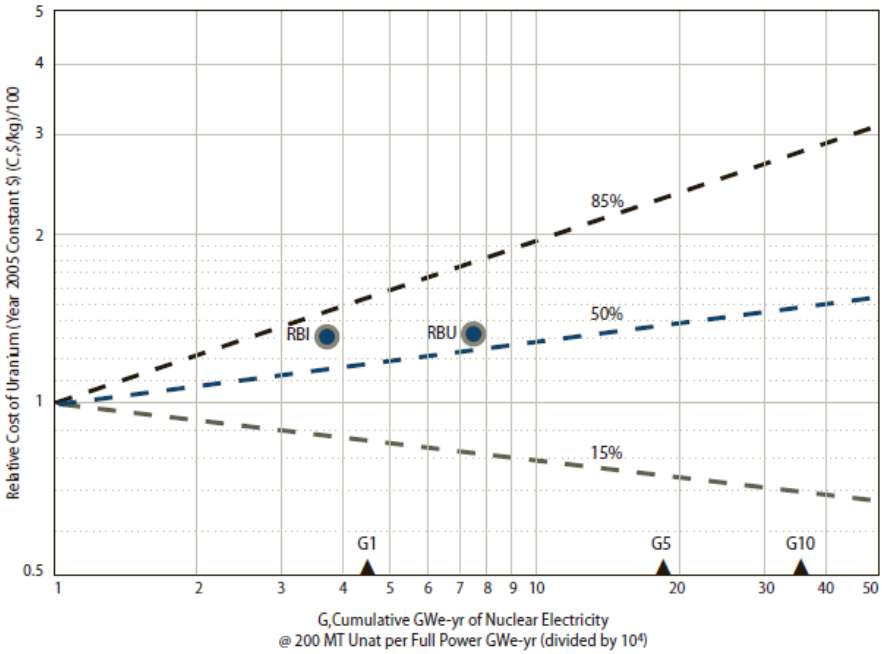


Figure 3.3 Relative Uranium Cost vs. Normalized Cumulative Nuclear Energy Generation



"Concerns about resource depletion should not motivate premature large scale deployment of alternatives to the current LWR once-through fuel cycle: there is time for a measured pace for introduction of alternatives."

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BRC Draft Report- July 29, 2011

The Blue Ribbon Commission concludes that the United States needs a new, integrated strategy for managing the back end of the nuclear fuel cycle, including a new approach to siting nuclear waste storage and disposal facilities. The recommended strategy has seven key elements:

1. **A New Consent- Based Approach to Siting**
2. **A New Organization to Implement the Waste Management Program**
3. **Access to Utility Waste Disposal Fees for their Intended Purpose**
4. **Prompt Efforts to Develop a New Permanent Geologic Disposal Facility**
5. **Prompt Effort to Develop One or More Consolidated Interim Storage Facilities**
6. **Support for Advances in Nuclear Energy Technology and for Workforce Development**
7. **Active U.S. Leadership in International Efforts to Address Safety, Non-Proliferation and Security Concerns**

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Additional Mission Impact – Blue Ribbon Commission on America's Nuclear Future

"The Commission concludes that the United States should continue to pursue a program of nuclear energy RD&D…to improve safety…and develop new technologies that could offer significant advantages"

Be attentive to opportunities in two distinct realms:

- "Near-term improvements in safety and performance of existing LWR technology…and in the technologies available for storing and disposing of SNF and HLW"
- "Longer-term efforts to advance potential "game-changing" nuclear technologies and systems that could achieve very large benefits"

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Blue Ribbon Commission Draft Report (cont.)

- Focus resources to address key gaps in U.S. nuclear RD&D infrastructure; leverage industry, national labs, and universities
- ATR NSUF is example of infrastructure available to scientists across the US; could yield very high returns on investment
- "NE R&D Roadmap provides good science-based approach to develop effective, long-term RD&D program…that involves a broad range of participants including universities, industry and national laboratories"
- "Commission recommends expanded federal, joint labor-management and university-based support for advanced science, technology, engineering, and mathematics training to develop the skilled workforce needed for effective waste management program and viable domestic nuclear industry."

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Issues Potentially Impacting University Awards in FY 2012

- **House Appropriations Committee Energy and Water Development (HEWD) Report (June 2011) recommends that not less than 10 percent of the total NE appropriation be fully and openly competed among national laboratories, universities, and U.S. industry.**

- **Integrated University Program (student fellowships and scholarships) not included in the NE FY 2012 budget request, but is included in HEWD Report.**

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NEUP Program Support in FY 2012: Two Main Program Areas

- **Fuel Cycle (FC R&D)**
  - Separations and Waste Forms
  - Advanced Fuels
  - Transmutation R&D
  - Systems Analysis and Integration
  - Materials Protection, Accounting, and Control Technology
  - Used Nuclear Fuel Disposition
  - Fuel Resources
- **Reactor Concepts (RC RD&D)**
  - Small Modular Reactors Advanced Concepts
  - Next Generation Nuclear Plant Demonstration Project
  - Light Water Reactor Sustainability
  - Advanced Reactor Concepts

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Summary of NE Funding for Universities

- **NE plans to continue its significant investment in university-based R&D and supporting activities through NEUP and other programs**
- **Up to 20% of RC R&D and FC R&D budget is allocated to the peer-reviewed NEUP**
  - Support for R&D and related infrastructure remain components of the NEUP scope
  - EPAct requirement for university cost share waived for NEUP
- **NE University Investments Outside of NEUP Solicitations**
  - Potential for competitively-awarded solicitations to universities, national labs, and industry under NEET Transformative
  - NE-funded fuel management support for university research reactors
  - National labs apply NE R&D funds to support specific R&D or support efforts at universities

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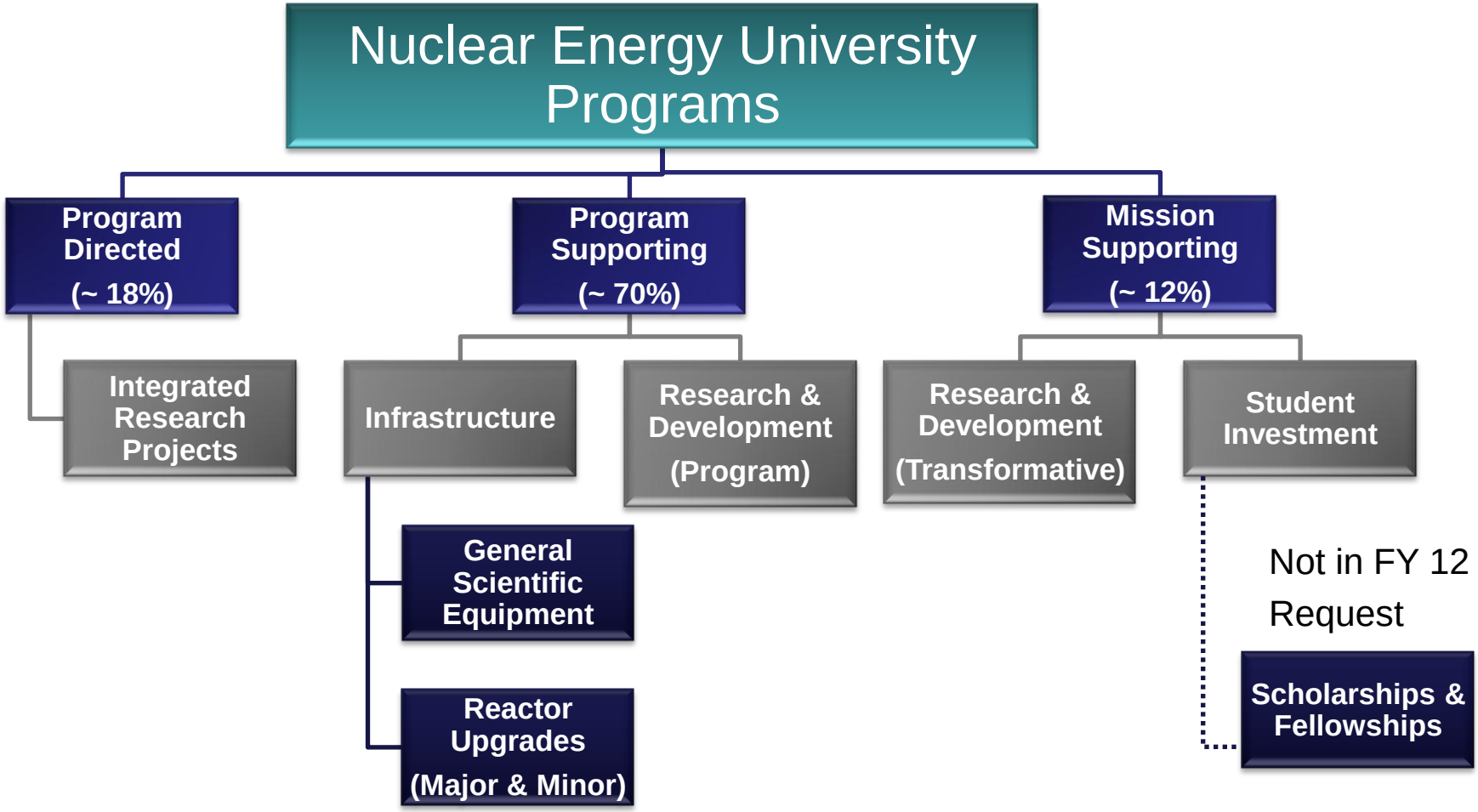
FY 2012 NEUP Structure



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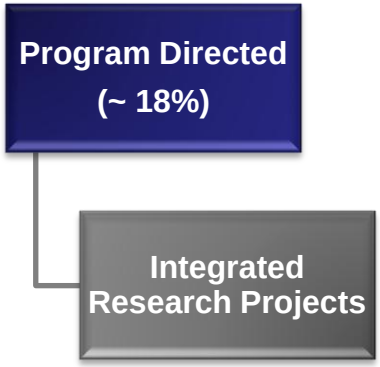
Program-Directed Component



- **Anticipate Two IRPs in FY 2012**
  - One funded and scoped by RC RD&D
  - One funded and scoped by FC R&D
  - Initial planning estimate is $1.5M per year per IRP for 3 years ($9M total)

- **In FY 2012, evaluation criteria weighting will remain 50% program relevance and 50% technical quality**
  - Peer review team evaluates technical quality
  - Federal Program staff evaluates relevance
  - If technical quality is evaluated as “not recommended”, or if evaluated as “not relevant”, project will not be funded

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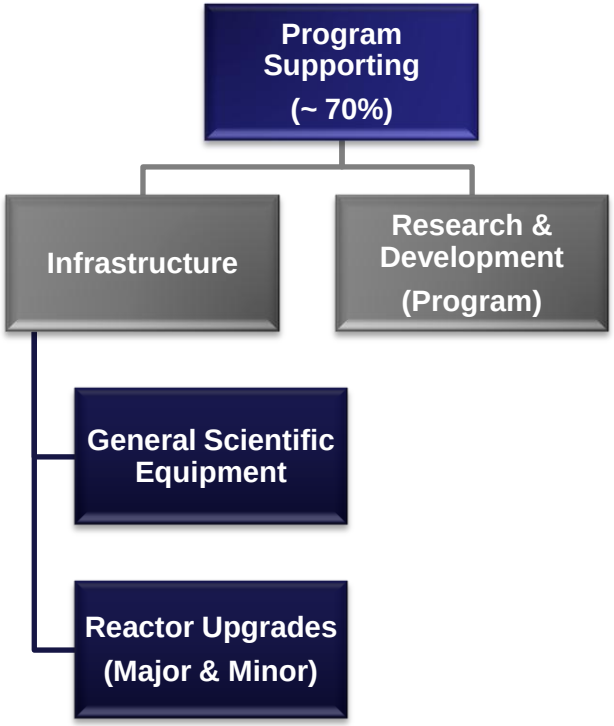
Program-Supporting Component



- **R&D Element:**
  - Anticipate continuing the maximum of $1.2M for three or four years (~$400k/yr)
  - Pre-applications and full proposals will continue to undergo peer review and relevancy review
- **Review weighting unchanged at 35% relevance and 65% technical quality**
- **Includes Infrastructure support (reactor upgrades and equipment). <u>Shift downward in funding assumption based on FY 2011 applications and evaluation results</u>.**

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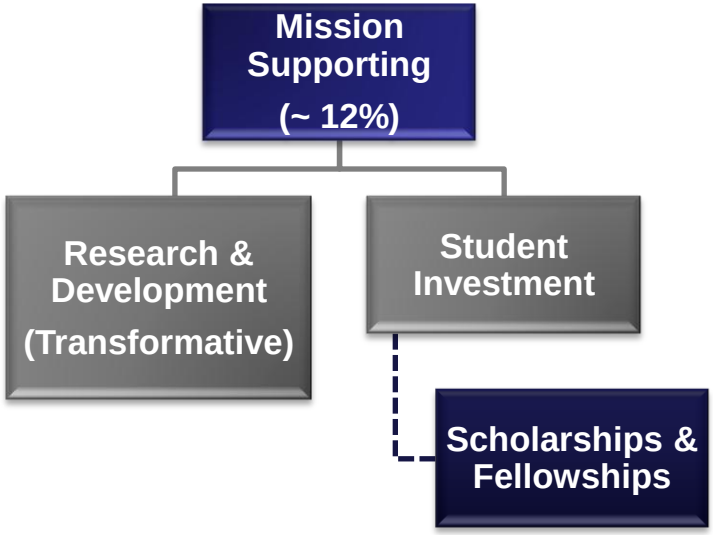
Mission-Supporting Component



- **R&D Component:**
  - Anticipate continuing maximum of $600K for three or four year projects (~$200k/yr)
  - Pre-applications and full proposals continue to undergo peer and relevancy review
- **Review weighting is 20% relevance and 80% technical quality**
- **Student investment not in FY 2012 request, but in HEWD Report**

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Improvements and Considerations for 2012

- **International Collaborations**
- **Develop and implement performance metrics**
  - Demonstrate program effectiveness
  - Help justify program funds
  - Build support (Congress, GAO, public)
- **Expand and improve the Peer Review data base**
- **Employ communication enhancements**
  - Social media and web-based/videoconferencing

We Need Your Feedback Throughout the Workshop and Your Support Throughout the Upcoming Year!

BACKUP SLIDES

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NE Program Changes in FY 2012

- **<u>Nuclear Energy Enabling Technologies (NEET) Program Shifts</u>**
  - Nuclear Energy Advanced Modeling and Simulation (NEAMS) funding consolidated to Crosscutting Technology Development
  - National Scientific User Facility (NSUF) funded under NEET
  - Modeling and Simulation Hub, NSUF, and Transformative activities executed via other competitions
  - NEET Transformative program supports, via an open, competitive solicitation process, projects relating to an aspect of nuclear energy generation, ensuring good ideas have sufficient outlet for exploration. Awards made to universities under these solicitations would represent a significant portion of mission supporting R&D funded by NE in FY 2012.

- **Reactor Concepts now includes Space and Defense RD&D – Radioisotope Thermal Generator (RTG) Technologies Included in NEUP MS workscopes**