U.S. DEPARTMENT OF ENERGY | Nuclear Energy

DOE Nuclear Energy Programs: The Long and the Short/the Far and the Near

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History

- **1946 -** Atomic Energy Commission authorized construction of Experimental Breeder Reactor I
- **1953 -** President Eisenhower delivers “Atoms for Peace” speech
- **1954 -** Eisenhower signs The Atomic Energy Act of 1954
- **1957 -** United Nations creates International Atomic Energy Agency (IAEA); first large-scale reactor comes on-line
- **1970 -** U.S., U.K., Soviet Union and 45 countries sign Treaty for Non-Proliferation of Nuclear Weapons
- **1971 -** Twenty-two commercial plants in full operation in the U.S.
- **1973 -** U.S. utilities order 41 nuclear power plants
- **1974 -** The Energy Reorganization Act of 1974 splits AEC into two agencies: ERDA and the NRC

History

- **1977 -** President Carter defers plans for reprocessing spent fuel indefinitely
- **1977 -** Carter signs the Department of Energy Organization Act, transferring ERDA functions to DOE
- **1979 -** Accident occurs at Three Mile Island
- **1980 -** DOE initiates Three Mile Island research & development program
- **1981** - President Reagan lifts ban on reprocessing
- **1985 -** The Institute of Nuclear Power Operations forms national accreditation academy for power plant training program
- **1986 -** Accident occurs at Chernobyl
- **1987 -** The Nuclear Waste Policy Act is amended
- **1991 -** One hundred and eleven nuclear power plants in operation in the U.S.

History

- **1992 -** The Energy Policy Act of 1992 reforms licensing process for nuclear power plants
- **1994 -** NRC issues design approval for two advanced power plant designs
- **1996 -** NRC grants full-power license for Watts Bar I, last power plant to come on-line in the U.S.
- **2000 -** NRC issued first-ever license extension for 20 more years of operation
- **2001 -** The National Energy Plan was published, including significant role for nuclear power
- **2002 -** DOE's Nuclear Power 2010 Program is released
- **2005 -** President Bush signs Energy Policy Act of 2005
- **2006 -** 68% of Americans in favor of nuclear energy

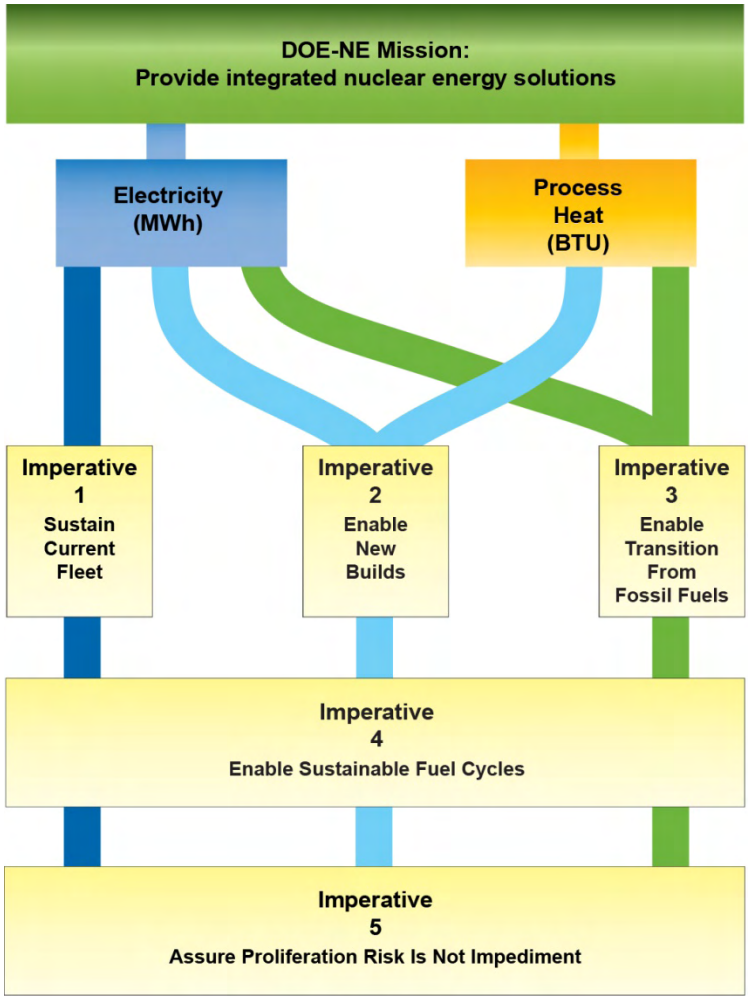
- **Mission –** The Office of Nuclear Energy promotes nuclear power as a resource capable of making major contributions to the Nation's energy security, environmental, and economic growth needs by resolving technical, cost, safety, security, and regulatory barriers through research, development, and demonstration.

- **Vision** – Increasing demand for clean, efficient, and economical energy generation technologies shapes NE's vision for today, tomorrow, and the future. NE envisions nuclear energy as a widely accepted, safe, clean, secure, and economically viable resource that helps meet our Nation's energy security goals, while contributing to global climate change abatement.

- **U.S. is among the countries highest in electricity use and CO2 emissions.**
- **The Department of Energy (DOE) aims to reduce CO2 emissions 80% by 2050.**
- **Nuclear power produces 20% or our total electricity and 70% of our non-greenhouse gas emitting electricity.**
- **To meet DOE's ambitious goals, 30% of electricity generation must be derived from nuclear power by 2030.**
- **In 2007, electricity generation accounted for 40% and transportation accounted for 33% of our total CO2 emissions.**

Goals

- From these observations, several strategic goals have been formed:
  1) Extend Plant Lifetimes
  2) Enable New Builds
  3) Reduce Carbon Footprint in Transportation/Industrial Sectors
  4) Develop Sustainable Fuel Cycle
  5) Understand/Avoid Proliferation Risks



Extend Plant Lifetimes - The Long

- Actions to extend the lifetime, improve the performance and sustain the health of the current fleet of nuclear power plants are vital. The U.S. depends on nuclear power today for most of our carbon-free electricity and must maintain that contribution and understand options to enhance its capability.

- **Enable New Builds - The Short and the Long/The Near and Far**
  - Significant builds of new plants will be required to merely maintain the current nuclear contribution. That implies continued improvements in the economics of nuclear power to enable new builds. And as large parts of our transportation sector transition to electric power and away from fossil fuels to avoid carbon emissions, the importance of new carbon-free electricity generation is intensified.

- **Reduce Carbon Footprint in Transportation and Industrial Sectors - The Short and the Long**
  - Reduction in the large use of fossil fuels in industrial process heat applications is critical. The heat generated by nuclear power can be harnessed for process heat without the burden of carbon emissions from fossil fuels, and we must understand how to optimize that application.

- **Develop a Sustainable Fuel Cycle - The Long**
  - Minimization of risks associated with nuclear energy can be achieved in part through developing a sustainable fuel cycle from perspectives of public acceptance, economics, safety and environment.

Understand and Avoid Proliferation Risks - The Far

- Another risk presented by nuclear power involves the proliferation of sensitive nuclear technologies and materials to nations that wish to develop nuclear weapons. Expansion of nuclear power around the world clearly requires careful attention to nonproliferation.

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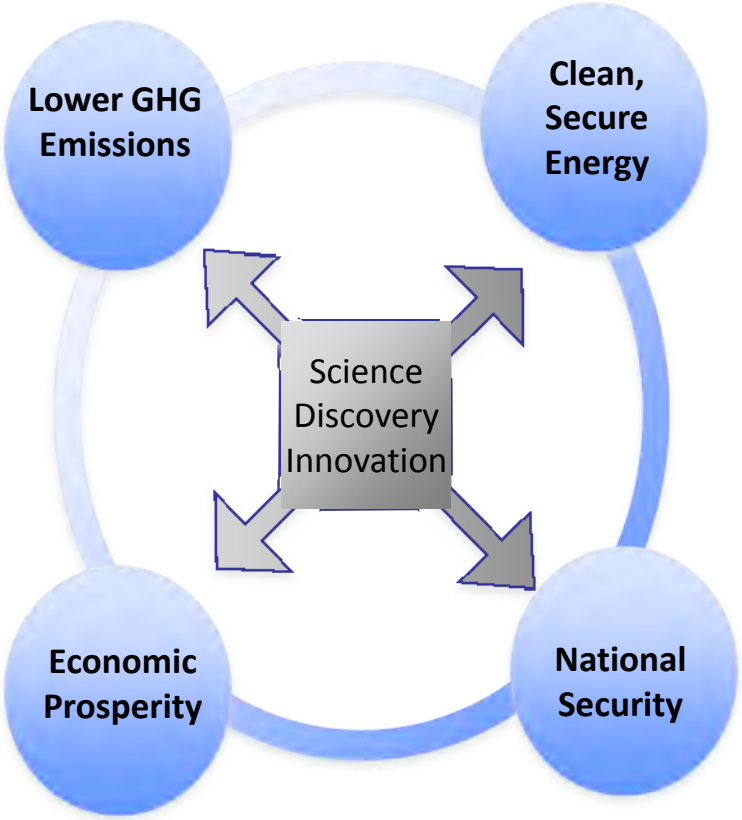
Nuclear Energy and Secretary Chu's Priorities

- **Science, Discovery & Innovation**
  - Embraces but also moves beyond incremental improvement of existing reactor and fuel cycle technologies to achieve transformational advances in knowledge and application.
- **Clean, Secure Energy**
  - Continues to provide at least 70% of the U.S. non-carbon generated electricity.
- **National Security**
  - Conducts and engages in partnerships and r&d is essential to understanding and reducing the risk of nuclear proliferation as nuclear-based power generation expands globally.
  - Contributes to reduction of petroleum imports through electrification of the transportation sector.
- **Economic Prosperity**
  - Advances U.S. technology leadership and global competitiveness and creates significant long-term employment and reliable and affordable electricity.
  - Contributes to reenergizing the U.S. nuclear infrastructure for global competitiveness.
- **Lower GHG Emissions**
  - Recognized as essential to addressing global climate change.



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Nuclear Energy

FY 2010 Budget

Program:	FY 2009 Appropriation	FY 2010 Cong. Request	FY 2010 Conference
Research & Development			
University Research	5,000	0	5,000
Nuclear Power 2010	177,500	20,000	105,000
Generation IV	178,649[a]	176,000[b]	220,137[b]
Nuclear Hydrogen Initiative	7,343[a]	0	0
Fuel Cycle R&D	142,652[a]	222,000[b]	136,000[b]
Infrastructure			
Radiological Facilities	66,146	77,000	72,000[c]
Idaho Facilities Management	140,000	203,402	173,000
Idaho Sitewide S&S	78,811	83,358	83,358
MOX Fuel Fabrication Facilities	487,008	0	0
Program Direction	73,000	77,872	73,000
Congressionally Directed Projects	**2,854**	**0**	**2,500**
Transfer from State Department	**3,300**	**0**	**0**
Use of Prior Year Balance Reduction	**-5,000**	**0**	**0**
Total NE:	**1,357,263**	**859,632**	**869,995**

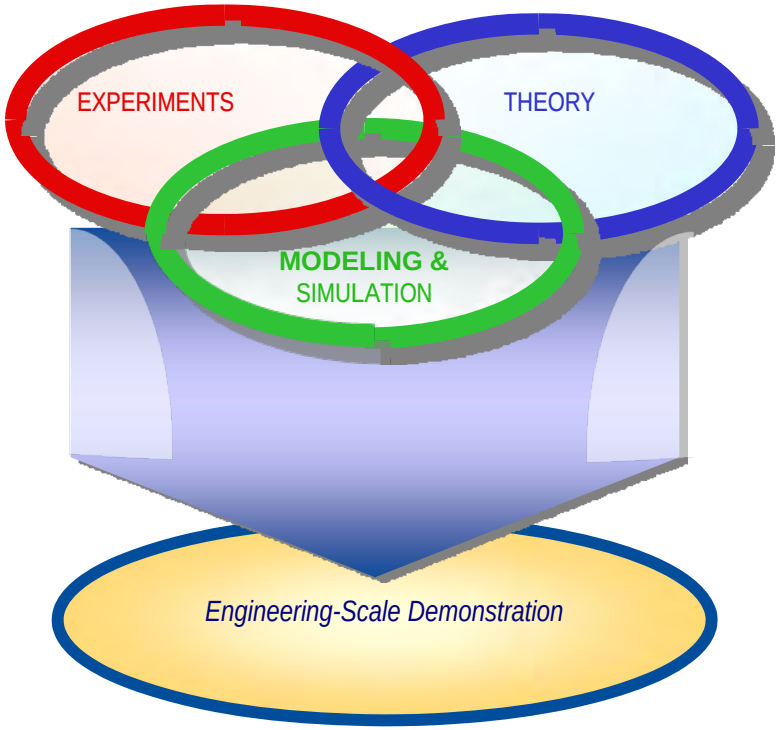
[a]SBIR/STTR not included

[b]Up to 20% of R&D funds are competitively awarded under NE University Programs

[c]Includes Space and Defense ($42M), Oak Ridge Nuclear Infrastructure ($10M), and Los Alamos Nuclear Infrastructure ($10M), Research Reactor Infrastructure ($10M)

Solution-Driven, Goal-Oriented, Science-Based Approach to Nuclear Energy Development

- **Experiments –** Small-scale experiments aimed at observation of isolated phenomena or measurements of fundamental properties. However, targeted integral experiments also will be needed in some cases.
- **Theory –** Theories are developed to explain the integral behavior of the system. These theories are benchmarked and validated against observations during integral experiments.
- **Modeling and Simulation –**In early-phases of development, modeling and simulation (M&S) tools are used to address scaling issues when large-scale applications are considered. A key objective of the M&S effort is to reduce the number of prototypes and large-scale experiments needed before demonstration and deployment.
- **Demonstrations -–** Nuclear systems must be deployed before they can impact and benefit society. Ultimately, new technologies, regulatory frameworks, and business models must be integrated into first-of-kind system demonstrations and prototypes whose construction and operation provide top-level validation of integrated system technical and financial performance.



Major elements of the science-based approach

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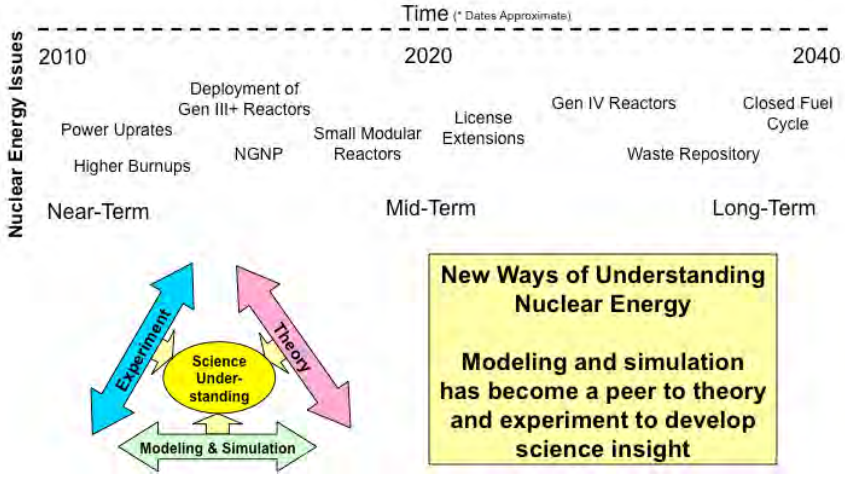
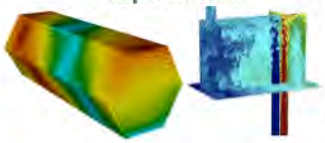
Concept Behind NE Modeling and Simulation Hub



New Ways of Understanding Nuclear Energy

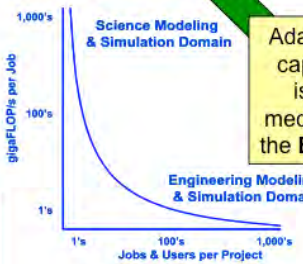
Modeling and simulation has become a peer to theory and experiment to develop science insight

Existing Advanced Modeling and Simulation Capabilities



Currently in the Science Domain

- Few users
- Few jobs
- Very big computers/job
- Long runtime



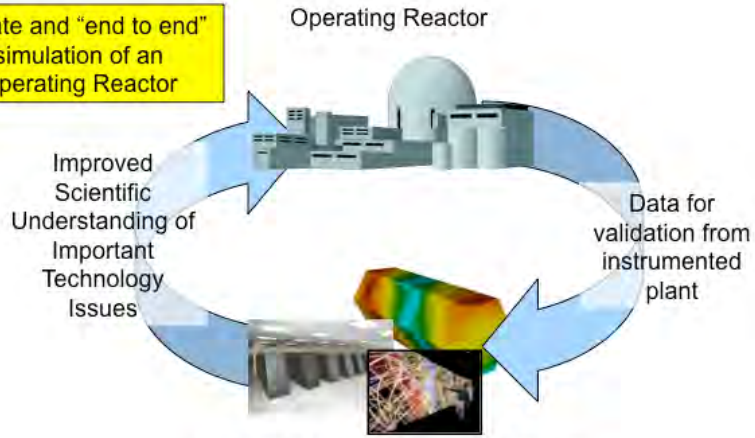
Adapt **Science Domain** capabilities to address issues for the near, medium and long term in the **Engineering Domain**

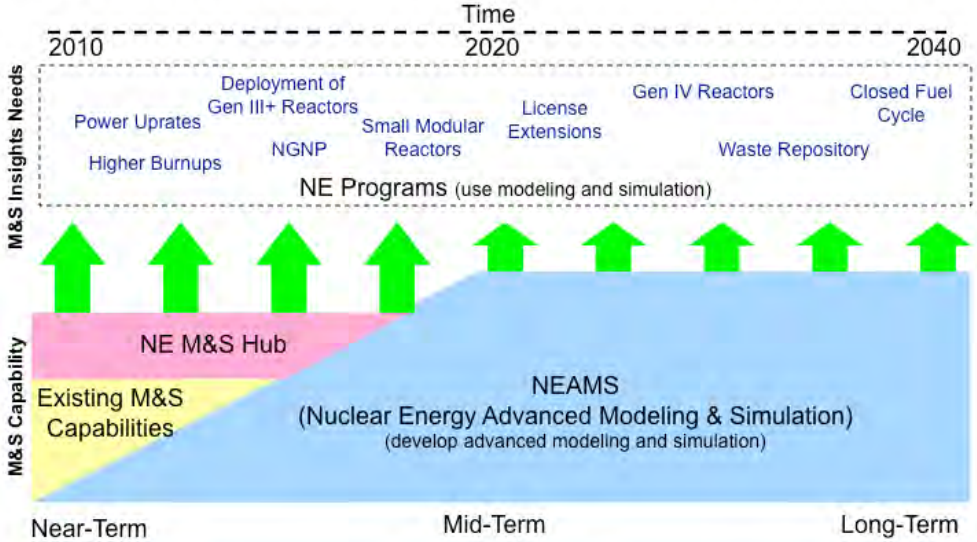
Change the Game by Accelerating the Use of Advanced Modeling and Simulation to Address Near Term Nuclear Energy Issues

Engineering analysis is different

- Short, high pressure timelines
- Requirement for many, short jobs
- Many users
- User environment straightforward

Create and "end to end" simulation of an Operating Reactor





Challenges

- **Four distinct issues affect reaching these goals:**
  1) Public Perception of Nuclear Energy
  2) Capital Cost of New Plants
  3) Solving the Nuclear Waste Problem
  4) Non-proliferation

Public Perception of Nuclear Energy

- Statistics have shown that the public's attitude towards nuclear energy power generation has changed dramatically since the mid-1980s. In a poll conducted in 2006 that asked whether or not the Nation should build more power plants in the future, 63 percent of the respondents were in favor of the measure, up from 47 percent in a similar survey in 1998.

Capital Cost of New Plants

- At five to seven billion dollars per reactor, the construction of new nuclear plants is a significant financial challenge for the average utility capitalized at $25 billion.

- **Non-proliferation**
  - New approaches are needed to understand and constrain proliferation risks.

Nuclear Waste

- Regardless of whether utilities build any new nuclear power plants, the country needs a long-term solution to the waste storage issue. All options require analysis and R&D to solve the long-term waste disposal problem whether or not the industry builds new nuclear power plants. Not solving the problem will hinder any additional use of nuclear power, thus eliminating a key component in any viable climate change abatement strategy.

Summary

- **Although there are many challenges, nuclear energy represents a significant portion of safe, secure, low-GHG base-load electricity production in the United States. Sustaining and expanding that contribution would contribute to the President's national objectives for the Department of Energy, including restoration of science leadership, reduction of GHG emissions, enhanced energy security through the displacement of foreign energy sources and the significant economic stimulation associated with new nuclear power construction.**