

# Long-Term R&D Activities in Support of Nuclear Power

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International Activities in Long Term Research Projects

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U.S. DEPARTMENT OF  
**ENERGY**

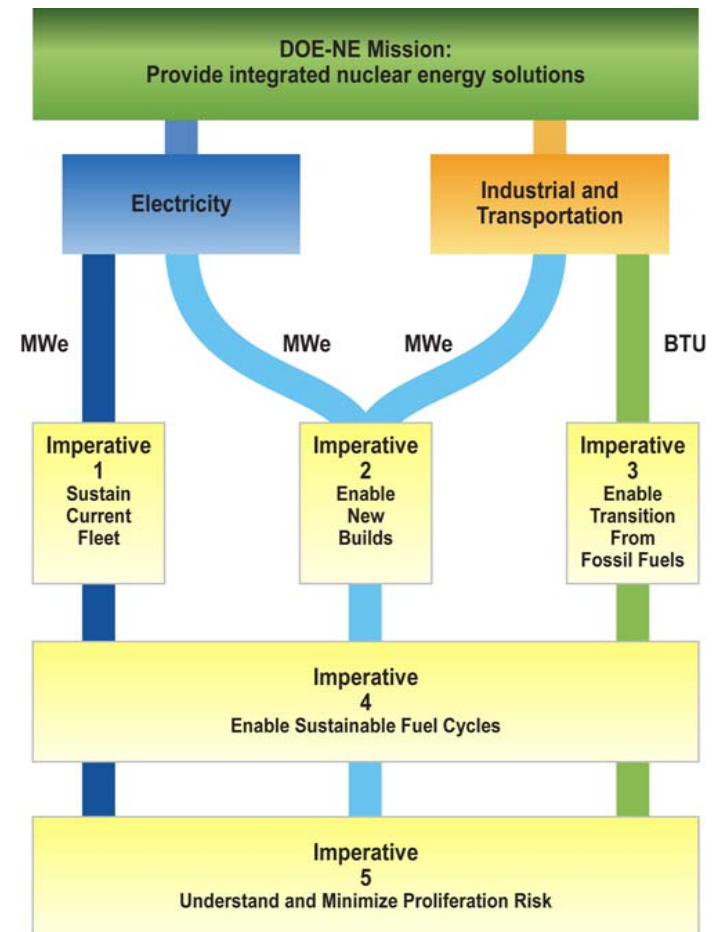
Nuclear Energy

## Office of Nuclear Energy's Mission

***The primary mission of the Office of Nuclear Energy 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.***

# Nuclear Energy Imperatives

- 1) **Extend life, improve performance, and sustain health and safety of the current fleet**
- 2) **Enable new plant builds and improve the affordability of nuclear energy**
- 3) **Enable transition away from fossil fuels in the transportation and industrial sectors**
- 4) **Enable sustainable fuel cycles**
- 5) **Understand and minimize proliferation risk**

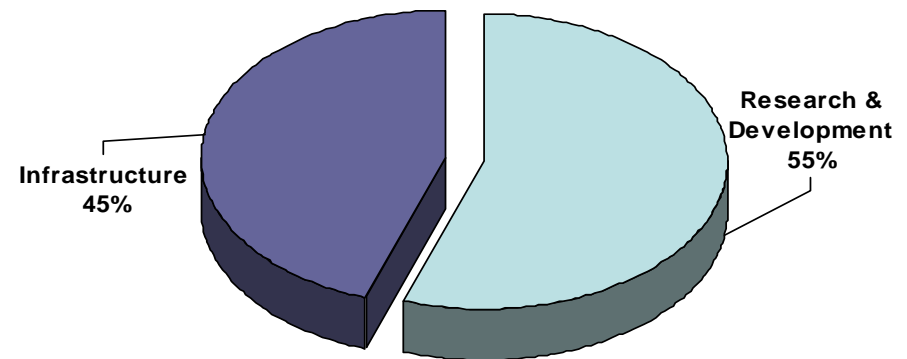


# Nuclear Energy RD&D: Reorganized and Refocused

◆ **New RD&D Agenda consists of three complementary and integrated programs:**

- Reactor Concepts RD&D (\$195M)
- Fuel Cycle R&D (\$201M)
- Nuclear Energy Enabling Technologies (\$99M)

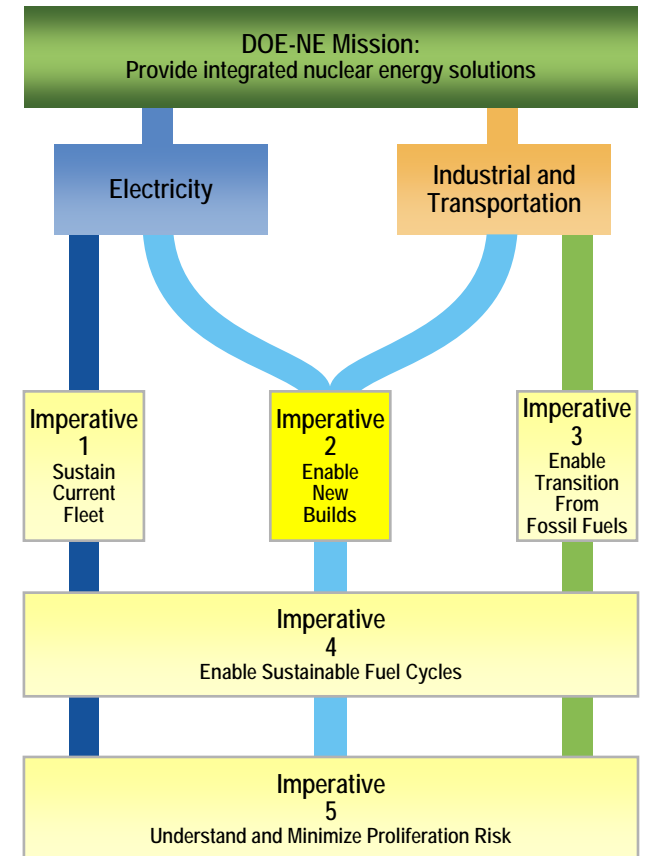
◆ **New RD&D Agenda supports the 5 NE Imperatives**



**NE Budget: \$912M**

# Reactor Concepts RD&D: Small Modular Reactors

- ◆ Explore advanced SMR concepts and develop advanced technology R&D that enable/enhance new SMR designs
- ◆ Engage National Laboratories, Universities, and Industry R&D communities
- ◆ Major areas of R&D will include:
  - Basic physics, materials, fuels, I&C, and fabrication research and testing
  - Modeling and simulation of reactor systems and components
  - Probabilistic risk analyses of innovative design features and safety systems
- ◆ Emphasis: simplified operation and maintenance, enhanced functionality, and increased proliferation resistance and security



# Reactor Concepts RD&D: Next Generation Nuclear Plant

## ◆ Fuel Development and Qualification

Establish licensing basis for gas-cooled reactor coated-particle fuel (several fuel tests in Advanced Test Reactor (ATR))

## ◆ Graphite Materials Qualification

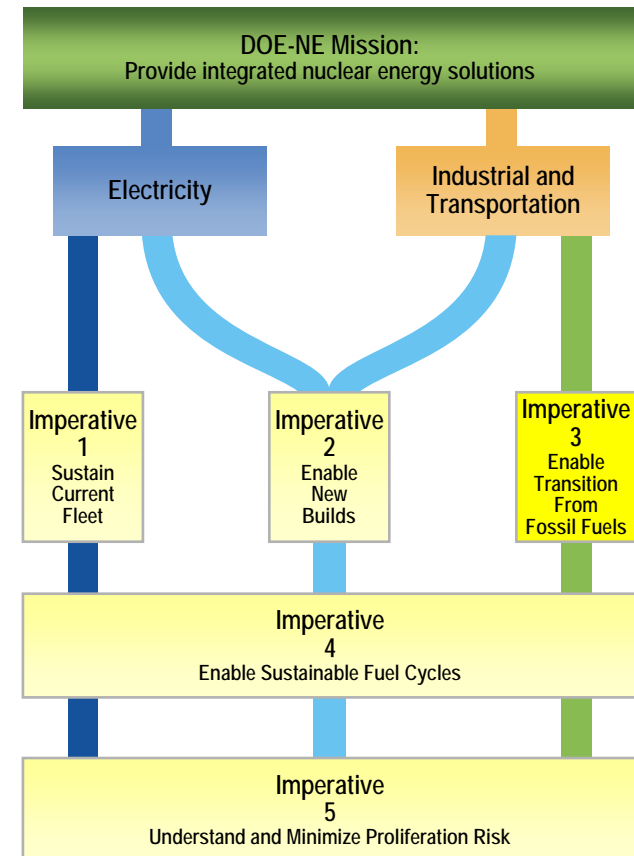
Used as an internal core structural material, moderator, and reflector (several tests in ATR and High Flux Isotope Reactor HFIR)

## ◆ High Temperature Material Qualification

Metals used in heat exchangers will be exposed to temperatures far greater than seen in Light Water Reactors

## ◆ Design and Safety Methods and Validation

Develop and benchmark improved simulation techniques, analytical codes, and methods



# Reactor Concepts RD&D: Light Water Reactor Sustainability

## ◆ Nuclear Materials Aging and Degradation

Develop science-based fundamental understanding of materials aging and degradation

## ◆ Advanced LWR Nuclear Fuel Development

Develop new long-life fuel using advanced materials, eliminate fuel failures, and achieve higher burn-up

## ◆ Advanced Instrumentation, Information, and Control Systems Technologies

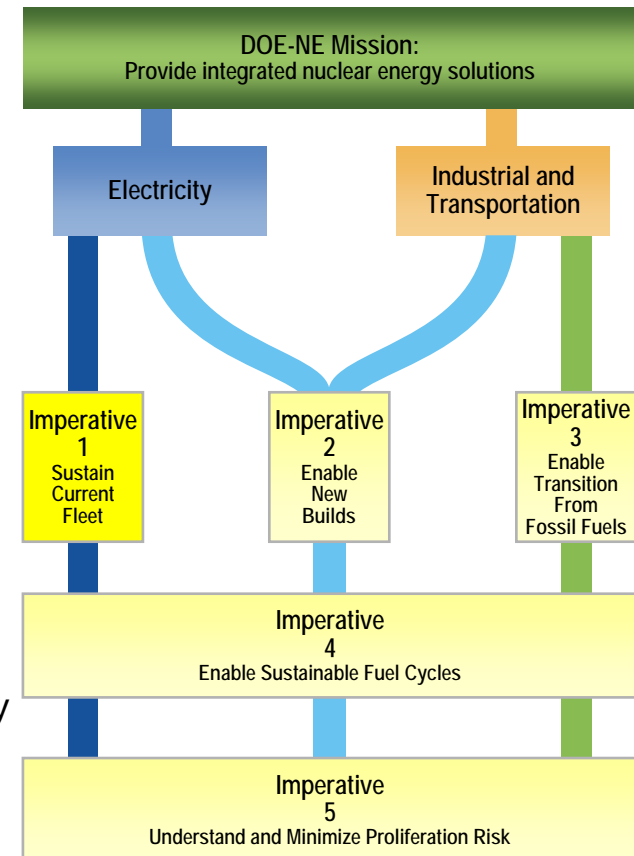
Develop new I&C systems and human/machine interface capabilities; support power up-rates and efficiency improvements; develop advanced condition monitoring and prognostics technologies

## ◆ Risk-Informed Safety Margin Characterization

Address aging effects to understand how safety margins change with age; develop improved analytical methods to enhance ability to accurately predict safety margins; support power up-rates

## ◆ Economics and Efficiency Improvement

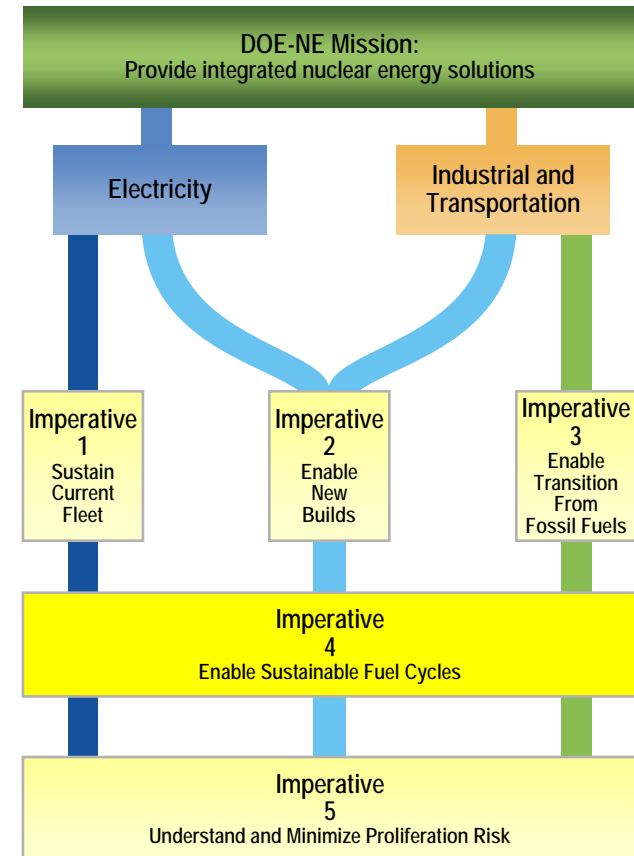
Address potential for capacity factor improvement as well as possibility of reduced operations due to droughts



# Reactor Concepts RD&D: Advanced Reactor Concepts

## ◆ Supports an expanded R&D program to encompass reactor technologies beyond Generation IV

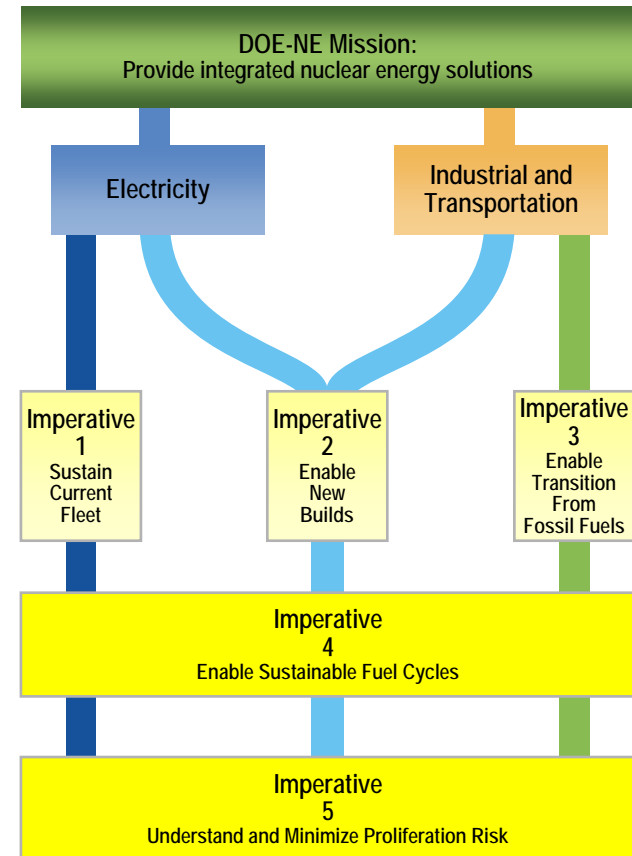
- Both advanced thermal and fast reactor systems will be considered
- Fast reactors could be employed to consume long-lived, high-activity elements from LWR spent fuels as part of a long term waste management approach
- Some R&D conducted with foreign researchers through the Gen IV International Forum (GIF)





## Fuel Cycle R&D

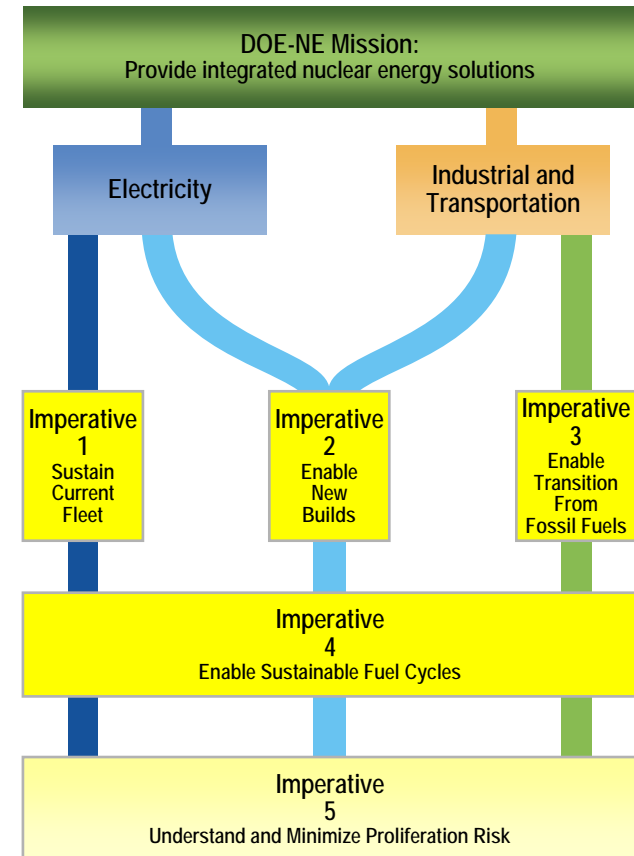
- ◆ Separations and Waste Forms
- ◆ Advanced Fuels
- ◆ Modeling and Simulation
- ◆ Systems Analysis and Integration
- ◆ Materials Protection, Accountancy, and Controls for Transmutation
- ◆ Used Nuclear Fuel Disposition
- ◆ Modified Open Fuel Cycle



# Nuclear Energy Enabling Technologies: Crosscutting Technology Development

◆ **Supports R&D in either crosscutting or enabling technologies to support multiple reactor concepts in following areas:**

- Reactor Materials – New classes of alloys and materials not yet considered for reactor performance may enable transformational reactor performance.
- Proliferation 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.
- 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.
- Advanced Sensors and Instrumentation – Research on unique sensor and instrumentation infrastructure technology to monitor and control new advanced reactors and small modular reactor systems.

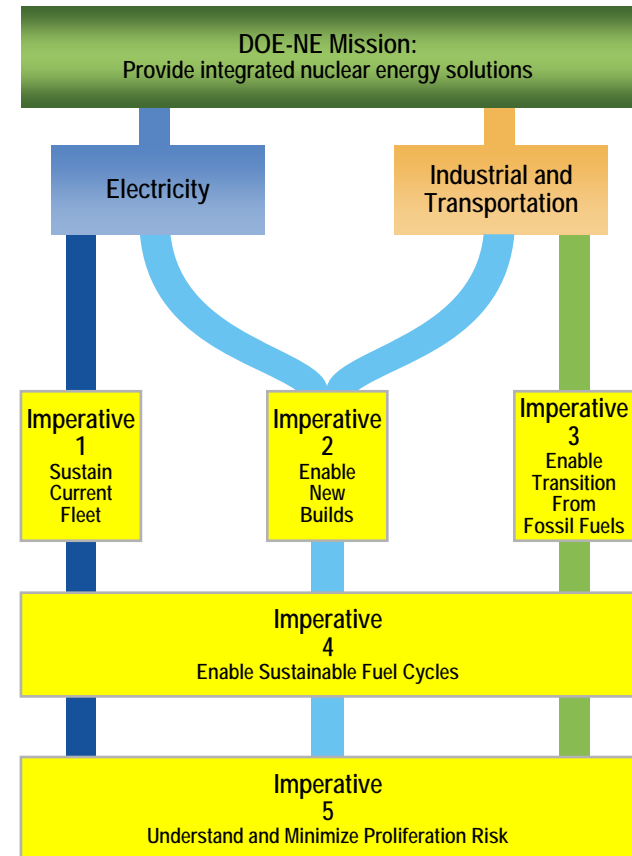


## Nuclear Energy Enabling Technologies: Transformative Nuclear Concepts R&D

◆ **Support investigator-initiated projects that relate to any aspect of nuclear energy generation via an open, competitive solicitation process**

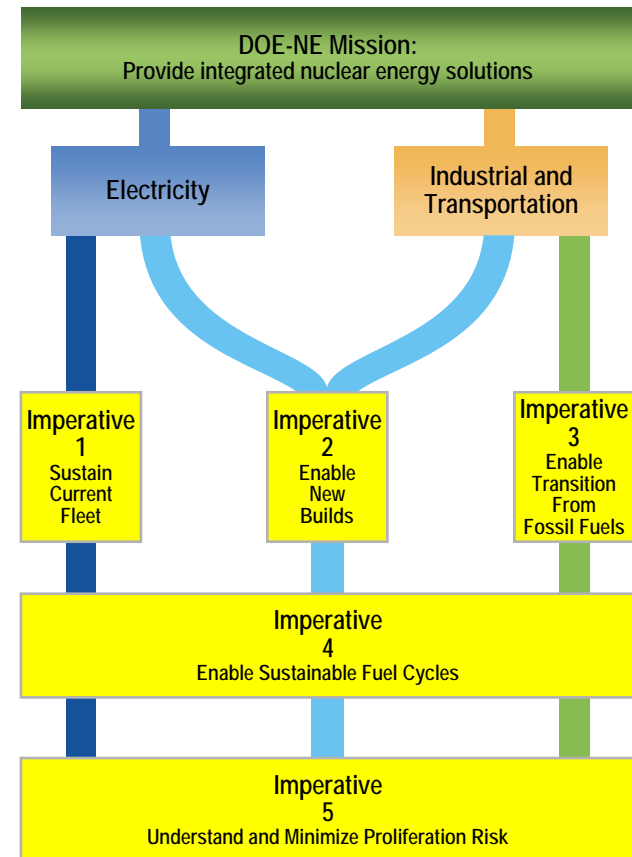
- Reactor and power conversion technologies
- Enrichment
- Fuels and fuel management
- Waste disposal
- Nonproliferation
- Other

◆ **Encourage “outside the box” options for nuclear energy**



## Nuclear Energy Enabling Technologies: Energy Innovation Hub for Modeling & Simulation

- ◆ Essential tool to improve our scientific understanding of reactor systems to increase the pace of innovation and reduce costs.
- ◆ Funding Opportunity Announcement issued on January 20, 2010.
- ◆ Focus on dramatically changing user environment for advanced modeling and simulation and high performance computing with mission focus to create a “virtual” model of an operating reactor.
- ◆ Exact scope of work to be performed will be defined by successful applicant.



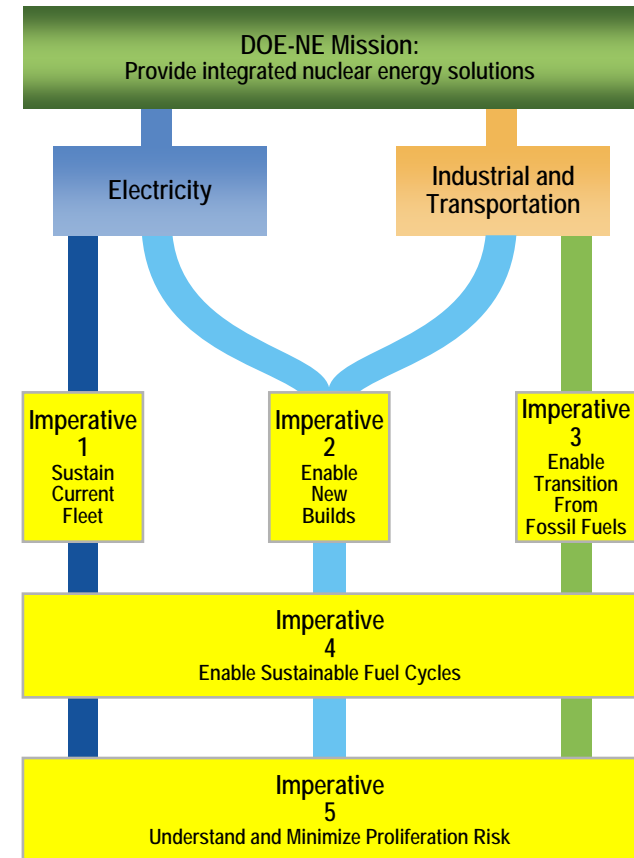
# Nuclear Energy University Programs

## ◆ Solicit Proposals and Award Universities (\$55.26M)

- **NE mission-specific and mission-relevant nuclear science and engineering R&D projects (70%)**
  - » 3-4 yr. projects
  - » Mission-specific R&D up to \$900K (~34 total)
  - » Mission-relevant R&D up to \$600K (~9 total)
- **Infrastructure grants (30%)**
  - » 1-yr. awards
  - » Equipment upgrades up to \$300K (~26 total)
  - » Reactor upgrade award up to \$1.5M (~2 total)
  - » Reactor Infrastructure up to \$200K (~7 total)

## ◆ Integrated University Program (\$5M)

- **Scholarship and fellowships grants**
  - » 1-yr. \$5K scholarships (~85 total)
  - » 1-yr. \$25K scholarships for outstanding students (~3 total)
  - » 3-yr. \$150K fellowships (~30 total)



## Nuclear Energy Success Path

- ◆ ***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. In some cases, targeted integral experiments may be needed.
  - **Theory** — Theories are developed to explain integral behavior of system. These theories are benchmarked and validated against observations during integral phenomena.
  - **Modeling and Simulation (M&S)** — In early phases of development, M&S tools are used to address scaling issues when large-scale applications are considered. A key objective of M&S effort is to reduce 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-a-kind demonstrations and prototypes whose construction and operation provide top-level validation of integrated system technical and financial performance.