



U.S. DEPARTMENT OF  
**ENERGY**

**Nuclear Energy**

# **Overview**

## **United States Nuclear Energy Policy**

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# U.S. DEPARTMENT OF ENERGY

# US Energy Supply and Demand

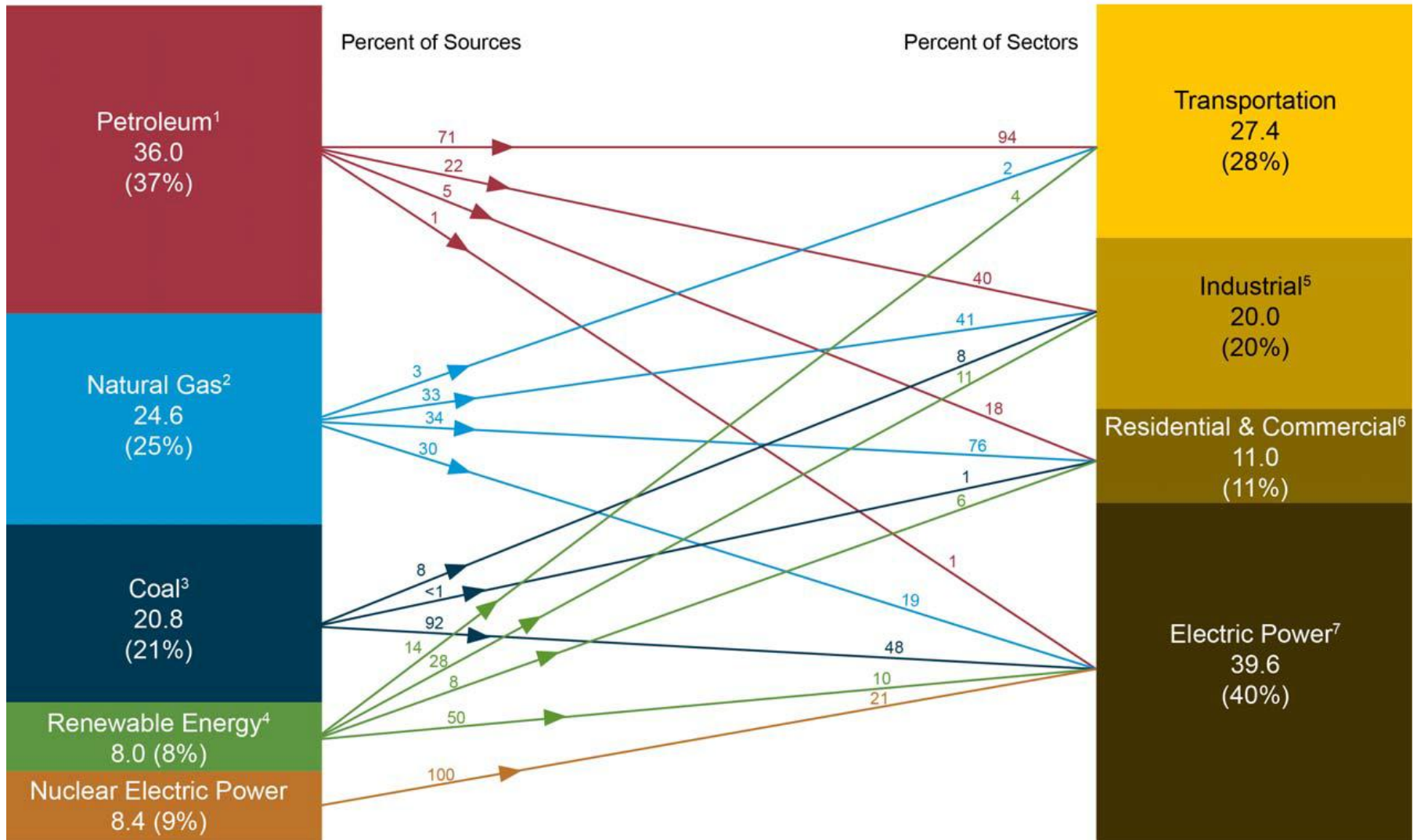
Source

Total = 98.0

Sector

Percent of Sources

Percent of Sectors





# Nuclear Energy

## Nuclear Energy *Plays an Important Role in US Energy Supply*

### ➤ Nuclear power is clean, reliable base load energy source

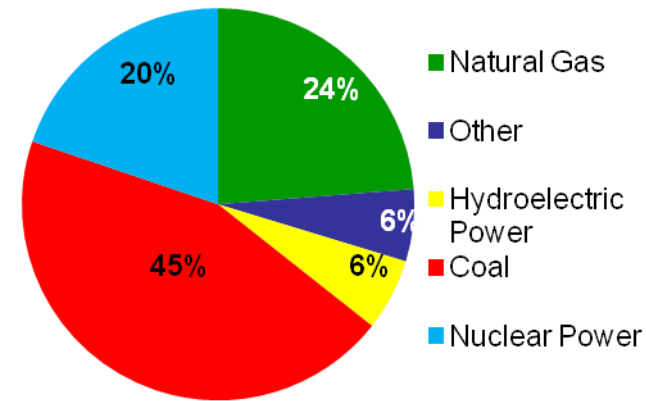
- Provides 19% of U.S. electricity generation mix
- Provides over 70% of U.S. emission-free electricity
- Avoids about 700 MMTCO<sub>2</sub> each year
- Helps reduce overall NOx and SOx levels

### ➤ U.S. electricity demand projected to increase ~24% by 2030

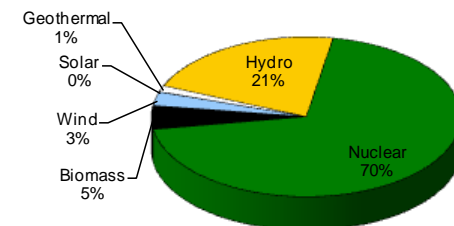
### ➤ 100 GWe nuclear capacity - 104 operating plants

- Fleet maintaining approximate 90% average capacity factors
- Most expected to apply for license renewal for 60 years of operation.

Power Generation by Source, 2010



Net Non-emitting (CO<sub>2</sub>) Sources of Electricity



# Fukushima Considerations

## Nuclear Energy

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### **62 Percent of the Public, 80 Percent of Plant Neighbors Favor Nuclear Energy in the United States, Perspective on Public Opinion, Nuclear Energy Institute, November 2011**

*“The public survey finds 62 percent in favor of nuclear energy and 35 percent opposed. Those strongly in favor outnumber those strongly opposed by two to one. Eighty percent of plant neighbors favor nuclear energy, and 19 percent are opposed. Those strongly in favor outnumber those strongly opposed by five to one.*”

*In the context of continuing news from Japan, the findings confirm that plant neighbor support is broad and deep. Those in favor of nuclear energy declined slightly, from 84 percent before Fukushima to 80 percent afterwards. Support among the public is also surprisingly deep, as seen in the moderate decline from 71 percent to 62 percent.”*



# Fukushima Dai-ichi Considerations



- 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”*



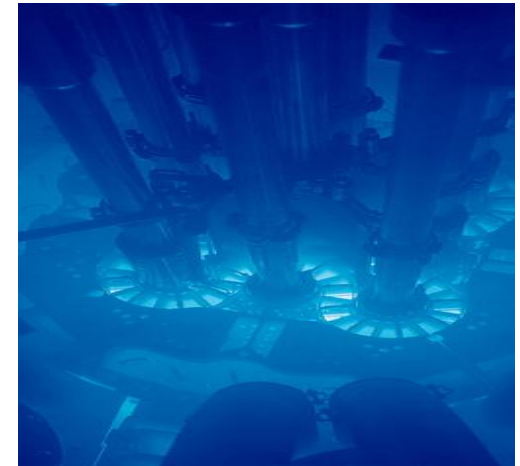
# Renewed Interest in Nuclear Energy in the U.S.

- **Early Site Permits:** 4 early site permits approved for Clinton, Grand Gulf, North Anna and Vogtle; additional permit applications filed.
- **License Applications:** 12 Construction and Operating License applications for 20 new reactors are under active review by the NRC; 71 reactor license renewals approved.
- **Reactor Design Certifications:** 2 designs have been certified; three new designs (APWR, EPR, and ESBWR) and 2 amendments (ABWR and AP 1000) are under review
- **New Plant Orders:** 4 EPC contracts signed; 9 power companies have placed large component forging orders.
- **Plant Construction:** TVA resumed construction activities at Watts Bar 2, and has decided to complete Bellefonte 1.
- **Financial Incentives:** Conditional loan guarantees approved for Vogtle NPP and Eagle Rock enrichment plant.



## Nuclear Energy

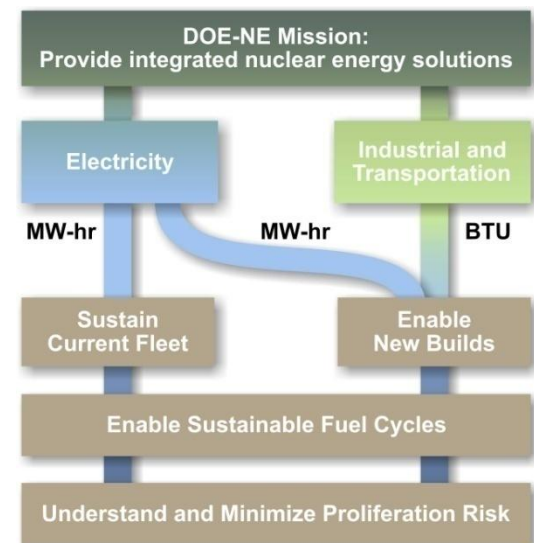
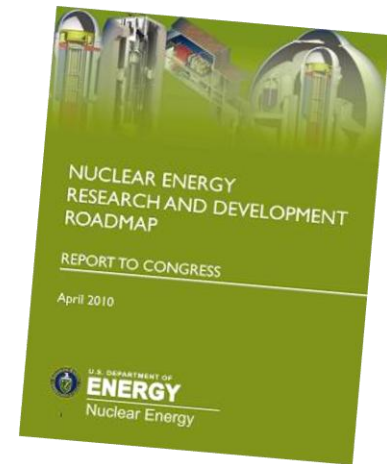
- Advance nuclear power as a resource capable of making major contributions in meeting the nation's energy supply, environmental, and energy security needs
- Resolve technical, safety, security, economic and regulatory issues, through targeted research, development, and demonstration (RD&D)
- Conduct R&D to enable the development and deployment of fission power systems for
  - Production of electricity (MWh)
  - Process heat (BTUs)





# Research and Development Objectives

- NE Roadmap outlines an integrated approach to meet domestic and international 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





# Objective 1: Maximize Use of Existing Nuclear Plants

- **100 GWe nuclear capacity - 104 operating plants**
- **Fleet maintaining greater than 90% average capacity factors**
- **Power up-rates continue**
  - As of April 2011, the NRC has approved 139 power uprates, resulting in a gain of ~6,020 Mwe, the equivalent of about 6 new reactors.
  - Additional uprates under NRC review.
- **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 1980s vintage knowledge bases and computational capabilities





# Light Water Reactor Sustainability

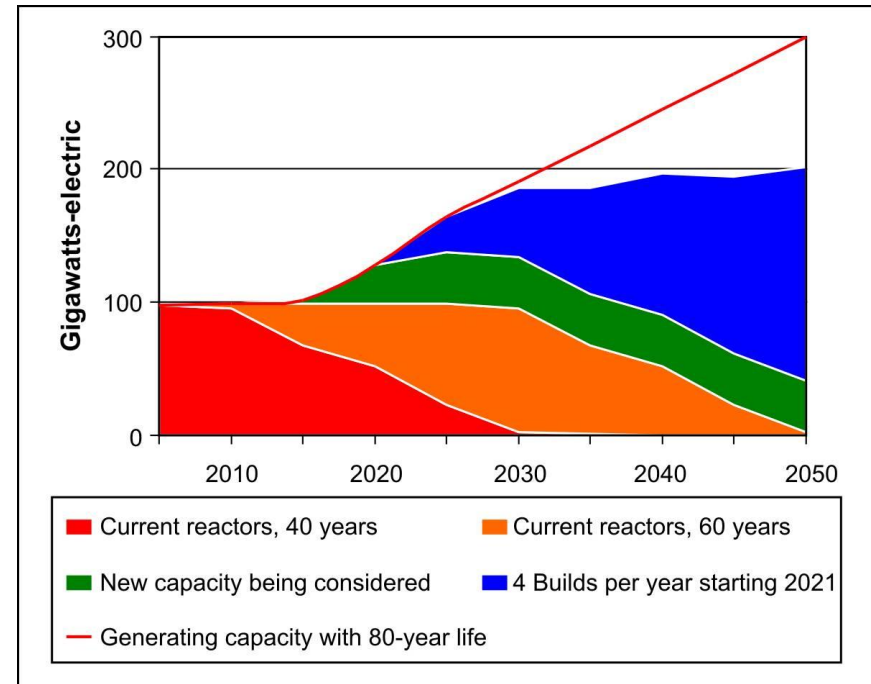
**Vision** - Enable existing nuclear power plants to safely operate beyond current license periods (beyond 60 years)

## 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





## Objective 2: Enable New Builds

### Nuclear Energy

#### ■ 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
- Deploy small modular reactors to reduce up-front capital costs
- Develop plant designs that address industrial needs



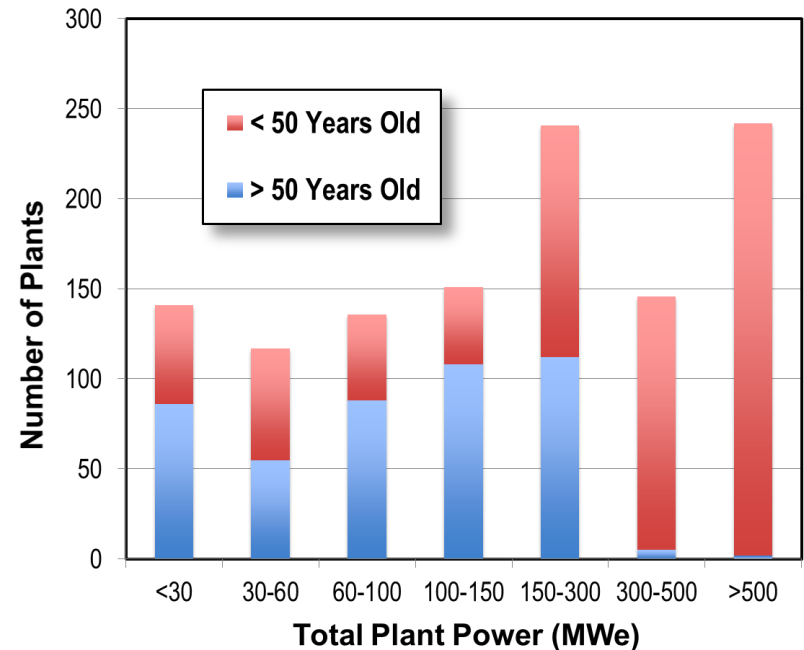


# Growing Interest in Small Modular Reactors (SMRs)

- 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**





# Energy Policy Act of 2005 - *Financial Incentives for First Movers*

## ■ Loan Guarantees

- Available for new reactors (up to \$18.5 billion) and front-end fuel cycle facilities (up to \$2 billion)
- Covers up to 80% of total project cost for up to 30 years
- DOE issued conditional commitment agreements totaling \$8.33 billion for financing of Vogtle 3 & 4 and \$2 billion for Eagle Rock enrichment plant.

## ■ Standby Support Delay Risk Insurance

- Covers cost of certain regulatory and litigation delays, up to \$2 billion
- Available for first 6 reactors that receive their COLs from the NRC
- Rule issued, no contract issued

## ■ Production Tax Credits

- Allows tax credits for electricity production from advanced nuclear power facilities for an 8-year period
- Allocates 1.8¢/kWh with a maximum of \$125 million per each 1,000 MW allocated per year
- National capacity limitation of 6,000 MW



*Construction activity at Vogtle*

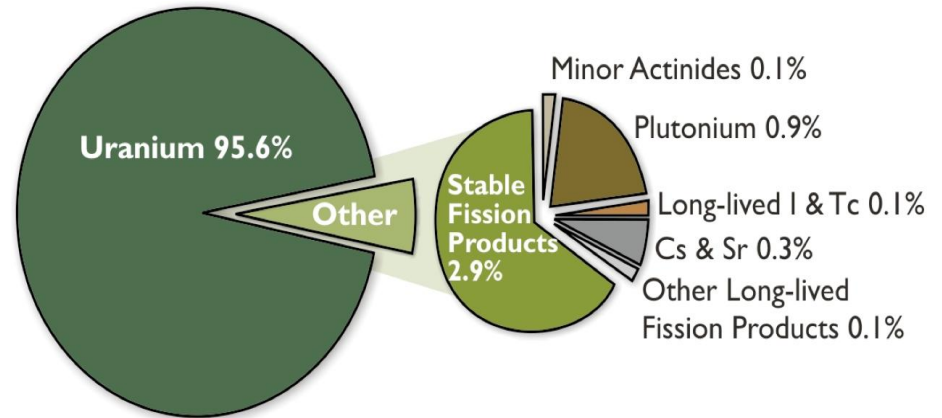


# Objective 3: Sustainable Fuel Cycles

## Nuclear Energy

- 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
  - Deploy preferred fuel cycle by 2050s

- Challenges
  - Develop high burn-up 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



# Fuel Cycle Research and Development

- Separations and Waste Forms
  - Minimize reprocessing, waste generation, and potential for material diversion
  - Develop waste forms for different waste streams and disposal environments
- Advanced Fuels
  - Develop accident tolerant fuel, higher burnup, better cladding, TRU bearing fuel forms
- Materials Protection, Accounting and Control Technology
  - Develop technologies and analysis tools for future fuel cycles to prevent diversion or misuse
- Fuel Resources
  - R&D on uranium extraction from seawater
- Used Nuclear fuel Disposition
  - R&D on long-term storage, transportation and disposal system performance in a range of geologic media



### Operating Facilities:

- *Paducah Gaseous Diffusion Plant (PGDP), Paducah, KY*
  - *Operated by USEC and leased from DOE. Capacity of 8 million SWU.*
- *URENCO USA Gas Centrifuge Plant, Eunice, NM*
  - *Commenced operations in June 2010. Planned capacity is 5.9 million SWU.*

### Planned Facilities:

- *Areva Eagle Rock Gas Centrifuge Plant, Idaho Falls, ID*
  - *Received NRC license in October 2011. Planned capacity is 3.3 million SWU.*
  - *On May 20, 2010, DOE granted a conditional commitment for a \$2 billion loan guarantee to support the construction of the Eagle Rock facility.*
- *USEC American Centrifuge Plant, Piketon, OH.*
  - *Planned capacity is 3.8 million SWU.*
- *General Electric Company is developing an advanced laser enrichment process based on the Separation of Isotopes by Laser Excitation technology (“SILEX”).*
  - *A license application was submitted to the NRC in June 2009*

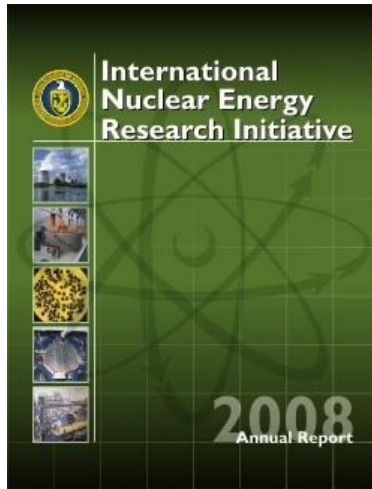


## Objective 4: Understand and Minimize Proliferation Risk

- **Goal is limiting proliferation and security threats by effective systems design and protecting materials, facilities, sensitive technologies and expertise.**
- **Challenges**
  - **Develop proliferation risk assessment methodologies and tools**
  - **Develop highly reliable, remote, and unattended monitoring technologies**
  - **Design improved safeguards into new energy systems and fuel cycle facilities**
  - **Develop advanced material tracking methodologies**



# International Cooperation



- Most NE programs have international components.
- International collaboration enables us to leverage resources, maximize work, and minimize duplication.
- We have bilateral and multilateral agreements in place to investigate advanced reactor concepts, fuel cycle technologies, and other areas of research, development and demonstration.





# International Cooperation

- **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
  - International Nuclear Energy Research Initiatives (I-NERIs) with France, Japan, Republic of 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)
  - OECD / Nuclear Energy Agency (NEA)



# Blue Ribbon Commission on America's Nuclear Future

- **President directed the establishment of the BRC in Jan 2010**
  
- **Final Report to the Secretary of Energy – January 29, 2012**
  - **A New Consent- Based Approach to Siting**
  - **A New Organization to Implement the Waste Management Program**
  - **Access to Utility Waste Disposal Fees for their Intended Purpose**
  - **Prompt Efforts to Develop One or More Permanent Geologic Disposal Facilities**
  - **Prompt Effort to Develop One or More Consolidated Interim Storage Facilities**
  - **Support for Advances in Nuclear Energy Technology and for Workforce Development**
  - **Active U.S. Leadership in International Efforts to Address Safety, Non-Proliferation and Security Concerns**



# 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.**

# Summary

## Nuclear Energy

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- DOE and the Administration continue to support nuclear energy to address carbon emissions and energy security goals
- DOE's mission is to help industry move technology to commercialization through targeted R&D by leveraging DOE resources to address and resolve technical challenges and risks to nuclear deployment
- Focus R&D on the continued safe operation of the U.S nuclear fleet and the development of new advanced technologies that improve safety and affordability
- Partner with the international community on mutually beneficial R&D