

SCHEDULING NOTE

Title: Meeting with Department of Energy (DOE) Office of Nuclear Energy (NE) (Public)

Purpose: To provide the Commission with information regarding items of mutual NRC and DOE/NE interest

Scheduled: June 20, 2016
9:00 am

Duration: Approx. 3 hours

Location: Commissioners' Conference Room, 1st fl OWFN

Participants:
Presentation

Department of Energy

50 mins.*

John Kotek, Acting Assistant Secretary for Nuclear Energy,
Department of Energy

Dr. John Kelly, Deputy Assistant Secretary for Nuclear Reactor
Technologies

Ray Furstenau, Associate Principal Deputy Assistant Secretary for
Nuclear Energy

Jon Carmack, National Technical Director for the DOE Fuel Cycle
Research & Development Advanced Fuels Campaign,
Idaho National Laboratory

Topics:

- DOE activities in the area of Advanced Reactors (Near term priorities and topics that could help NRC planning efforts for advanced reactor work)
 - Small Modular Reactors
 - Gateway for Accelerated Innovation in Nuclear (GAIN) & Internationalizing GAIN
 - Test/Demo Reactor Study
- Light Water Reactor Sustainability Program
- Accident Tolerant Fuel Program
- Grants and Fellowships
- Developing Human Capital for the Nuclear Sector (through Universities and Research and Development Programs)

Commission Q & A

40 mins.

NRC Staff

50 mins.*

Victor McCree, Executive Director for Operations

Jennifer Uhle, Director, Office of New Reactors

Michael Weber, Director, Office of Nuclear Regulatory Research

Bill Dean, Director, Office of Nuclear Reactor Regulation

Topics:

- Activities and planning efforts for advanced reactor work
- Status of small modular reactor licensing activities
- Subsequent License Renewal
- Research
- NRC Grants Program

Commission Q & A

40 mins.

Discussion – Wrap-Up

5 mins.

*For presentation only and does not include time for Commission Q & A's



U.S. DEPARTMENT OF
ENERGY

Update on Nuclear Reactor RD&D Program

Nuclear Regulatory Commission Briefing

Office of Nuclear Energy

John E. Kelly

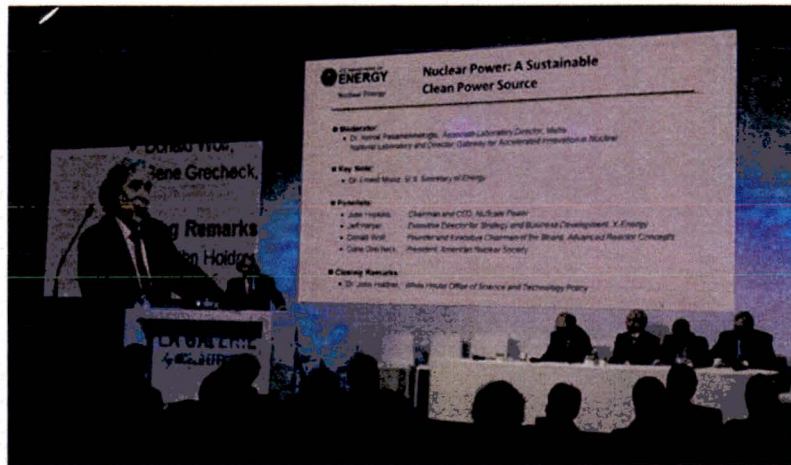
Deputy Assistant Secretary for Nuclear Reactor Technologies

U.S. Department of Energy

June 20, 2016

Nuclear Energy – Sustainably Clean Power

"To meet our emissions reduction targets and avoid the worst effects of climate change, we need to dramatically reduce power sector emissions. Switching from coal to natural gas is already reducing the U.S. carbon footprint, but it's not enough to get the deep CO₂ cuts envisioned in the President's Climate Action Plan. Reducing emissions by 80% will likely require the complete decarbonization of the power sector...."

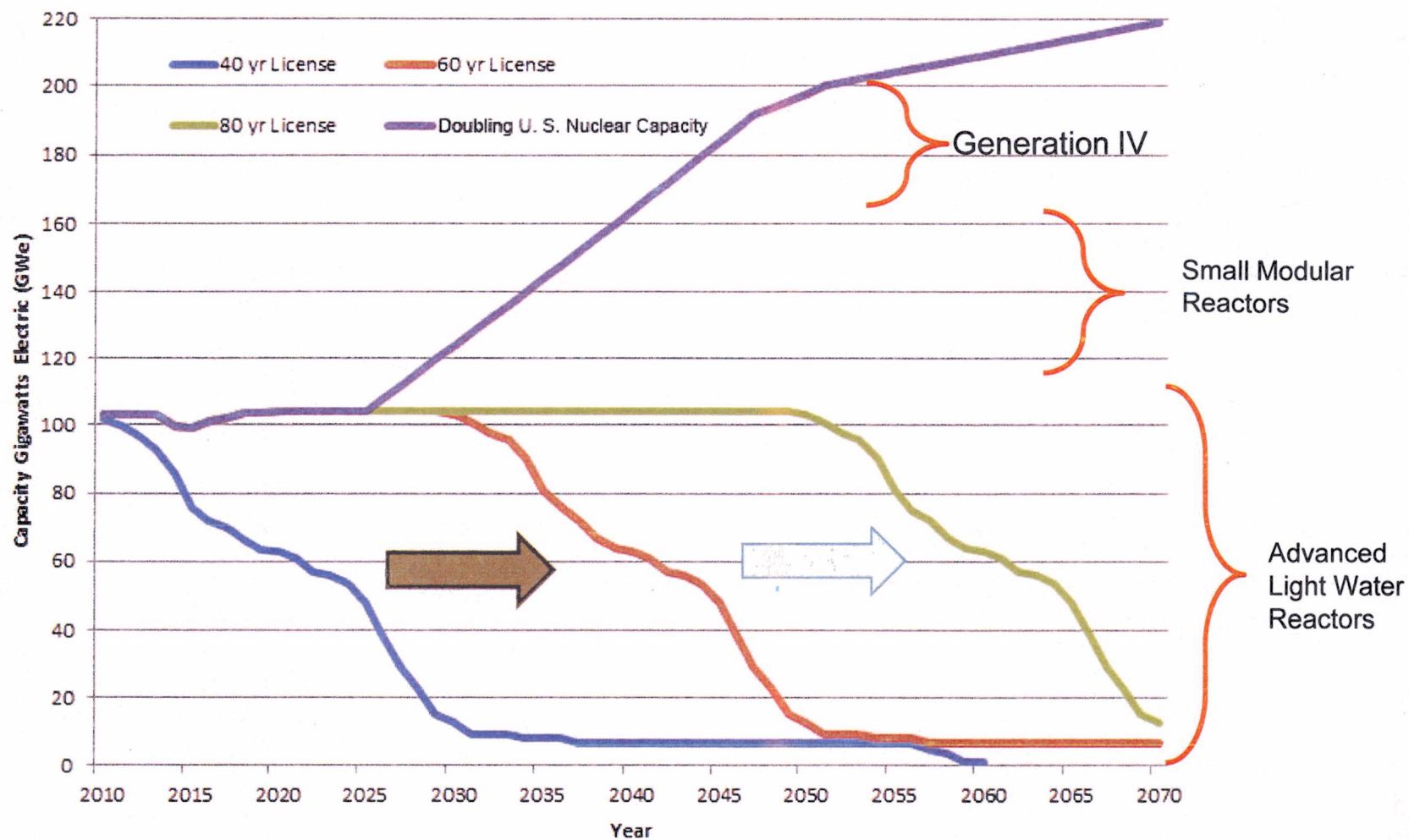


Secretary Moniz
COP21, Paris 2015

We know nuclear can provide 24-hour baseload power, because it already does. Worldwide, nuclear power produces more energy than hydro, solar, wind, and geothermal power combined.

The bottom line is that to achieve the pace and scale of worldwide carbon reductions needed to avoid climate change, nuclear must play a role."

Nuclear Power Capacity needed to meet Clean Power Goals



Light Water Reactor Sustainability (LWRS) Program

- LWRS Program Goal
 - Develop fundamental scientific basis to allow continued long-term safe operation of existing LWRs (beyond 60 years) and their long-term economic viability
- LWRS focus areas
 - Materials Aging and Degradation
 - Advanced Instrumentation and Controls
 - Risk-Informed Safety Margin Characterization
 - Systems analysis of emerging issues
 - Reactor Safety Technologies
- Coordination with NRC and EPRI has and will continue to be needed for success
- Data from LWRS program will support the recently announced plants seeking Subsequent License Renewal



Nine Mile Point ~ Courtesy Constellation Energy

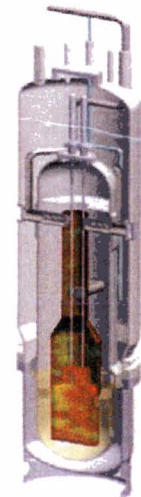
Accelerating SMR Deployment

SMR Licensing Technical Support Program

- Initiated in FY12 / A 6-year, \$452M program
- Mission
 - Accelerate the deployment of SMRs by supporting certification and licensing for U.S.-based SMR projects through cost-shared cooperative agreements with industry partners
 - Design Certification of NuScale SMR
 - Site Permitting and Licensing for Tennessee Valley Authority (TVA) and Utah Associated Municipal Power Systems (UAMPS)
 - Resolve generic SMR issues to improve the potential for commercialization, such as:
 - User requirements for SMRs
 - Technical analyses to address licensing concerns
 - Economic and Market analysis
 - Siting studies

SMR Program Status

- NuScale
 - Design Certification Application (DCA) Design Freeze completed at end of May 2016 - Next Steps:
 - Complete the final design review for the reactor module
 - Complete final Thermal-Hydraulic testing runs and reports
 - Finalizing DCA for December 2016 submission
- TVA Siting
 - Submitted Early Site Permit Application to NRC May 12, 2016 - Next steps: NRC acceptance review and review schedule development
 - TVA to begin technology selection activities in Fall 2016 followed by commencement of COLA development
- NuScale/UAMPS Siting
 - Site use agreement for a site on the INL reservation
 - Final stages of Site Selection (4 candidate sites on INL reservation; Site Selection report completed)
 - UAMPS Decision to Proceed to be made in August 2016

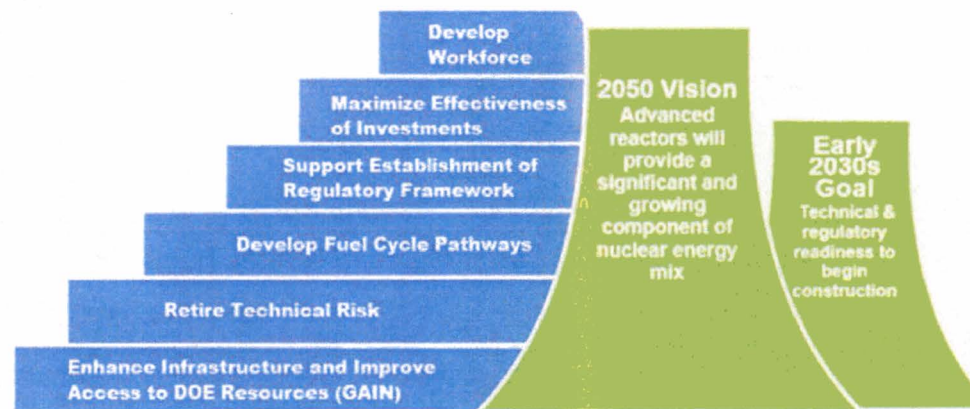


Support for SMR Commercialization

- NE identifying options for SMR commercialization beyond the LTS program
- Under consideration:
 - Support for Design Finalization for most mature SMR designs
 - Continue to build customer base by supporting additional COLAs
 - Further development of manufacturing technologies that would be important to the SMR manufacturing enterprise.
 - Supporting the development of alternative SMR applications, such as non-electrical uses and nuclear/renewable hybrid energy systems
- NE working closely with NEI and industry partners to understand market dynamics
- Workshop June 22-23, 2016 to solicit feedback from stakeholders

Vision and Strategy for Advanced Reactors

- To meet the challenge, DOE has developed a *Vision and Strategy for the Development and Deployment of Advanced Reactors* (<http://energy.gov/ne/downloads/draft-vision-and-strategy-development-and-deployment-advanced-reactors>)
 - The 2050 vision is for advanced reactors to be a significant part of the nuclear energy mix, and the goal is to have at least 2 concepts ready for deployment in the early 2030's
- DOE Vision and Strategy document is well aligned with those from NRC and NEI



Vision and Strategy for Advanced Reactors

Advanced Test and Demonstration Reactor Study

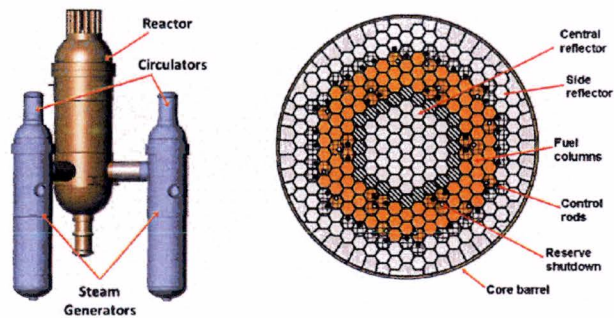
- Test Reactor – Irradiation Services:
 - Primarily for R&D
 - Provides appropriate environment
 - Must support development of advanced reactors
- Demonstration Reactors – Technology Validation
 - Demonstrate integrated reactor technology
 - Demonstrate transient performance
 - Provides flexibility to swap out components
 - Provides feedback on design, construction and operations

Strategic Objectives

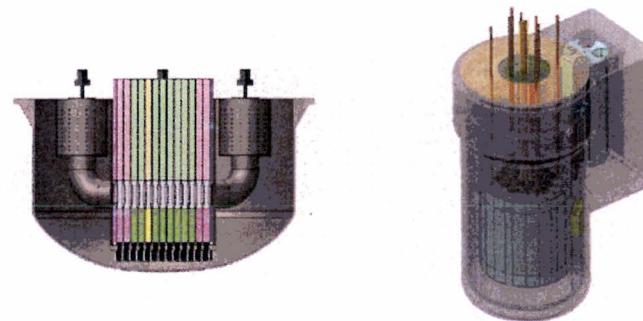
- **Demonstration Reactors:** fundamental mission is to provide efficient, reliable electricity production without carbon emissions
 1. Deploy a **high temperature process heat application** for industrial applications and electricity demonstration using an advanced reactor system to illustrate the potential that nuclear energy has in reducing the carbon footprint in the US industrial sector
 2. Demonstrate **actinide management** to extend natural resource utilization and reduce the burden of nuclear waste for future generations
 3. Deploy a **small scale demonstration reactor for a less mature reactor technology** with the goal of increasing the technology readiness level of the overall system for the longer term
- **Irradiation Test Reactor:** Built upon a reliable platform
 4. Provide an **irradiation test reactor** to support development and qualification of fuels, materials and other important components (e.g. control rods, instrumentation) of both thermal and fast neutron-based Generation IV advanced reactor systems

Preliminary Options

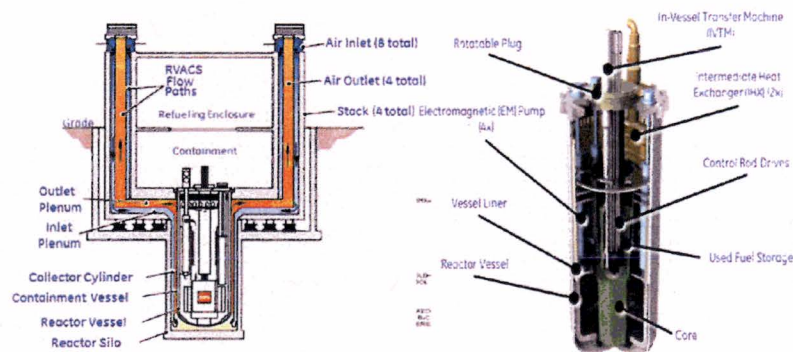
Strategic Objective 1: Process heat demonstration – modular HTGR



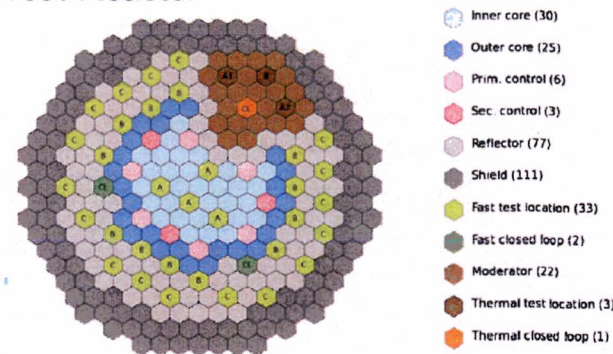
Strategic Objective 3: Demonstrating a Less Mature Technology – FHR or LFR



Strategic Objective 2: Resource Utilization and Waste Management – SFR

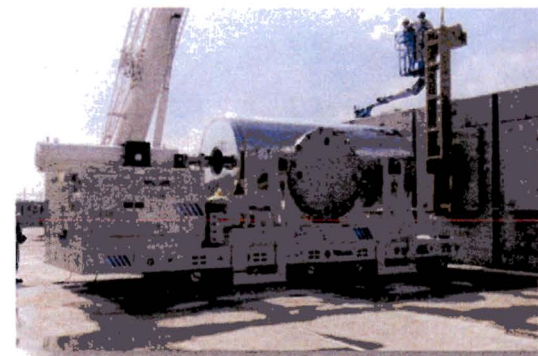
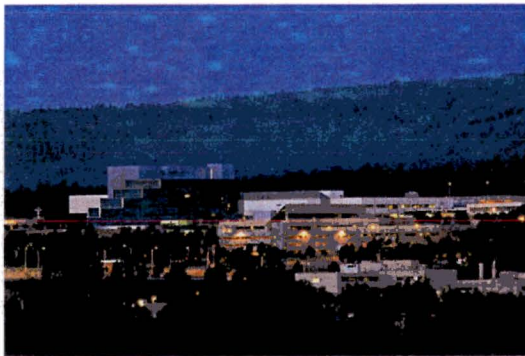


Strategic Objective 4: Test Reactor to Provide Neutrons – Sodium-cooled Fast Test Reactor



Summary

- Nuclear power must be a major source of our energy production to meet our clean energy goals
- Continue the safe and reliable operation of the current fleet
- Deploy SMRs in mid-2020's
- Develop advanced reactor technologies (Generation IV) for deployment in the early 2030's





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ENERGY

Update on Nuclear Energy Innovation

Nuclear Regulatory Commission Briefing
Office of Nuclear Energy

Ray Furstenau

Associate Principal Deputy Assistant Secretary for Nuclear Energy

U.S. Department of Energy

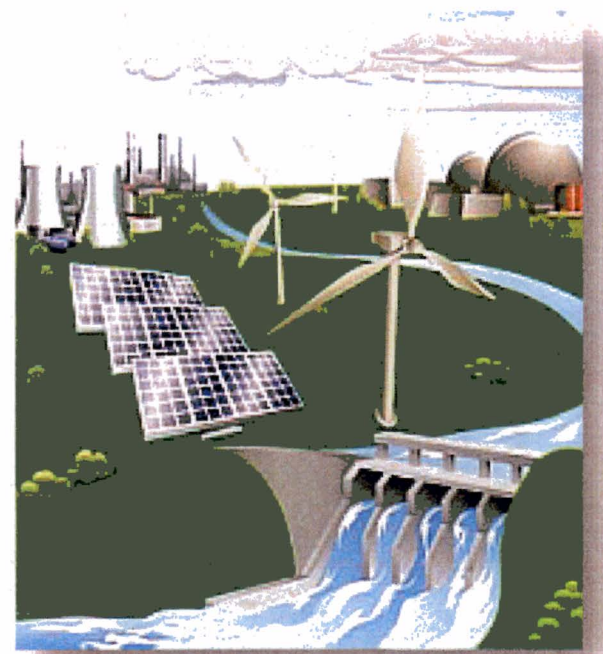
June 20, 2016

Outline

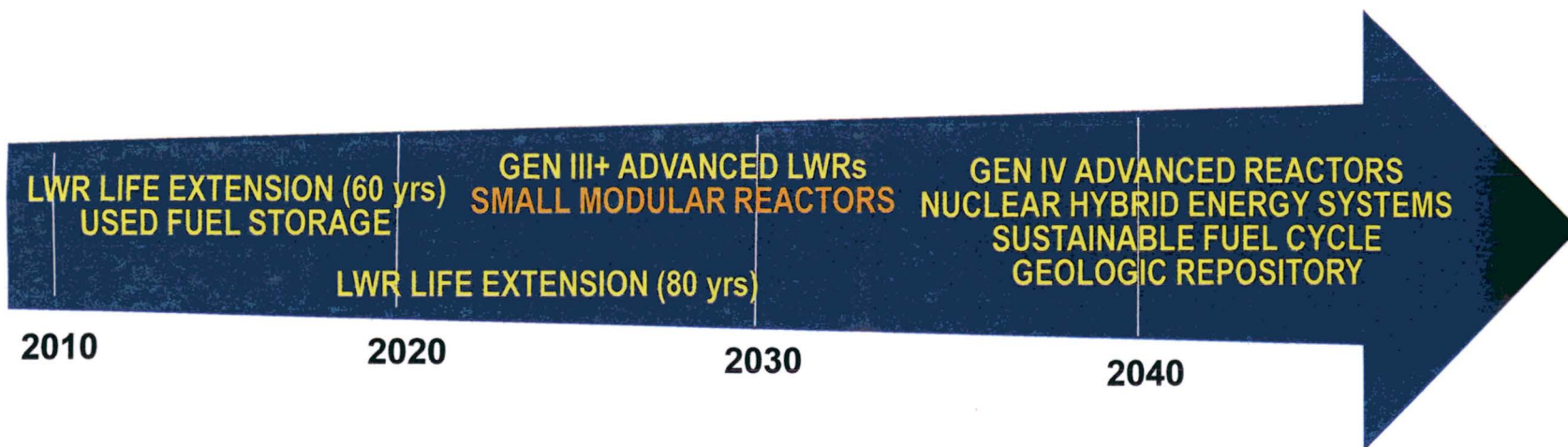
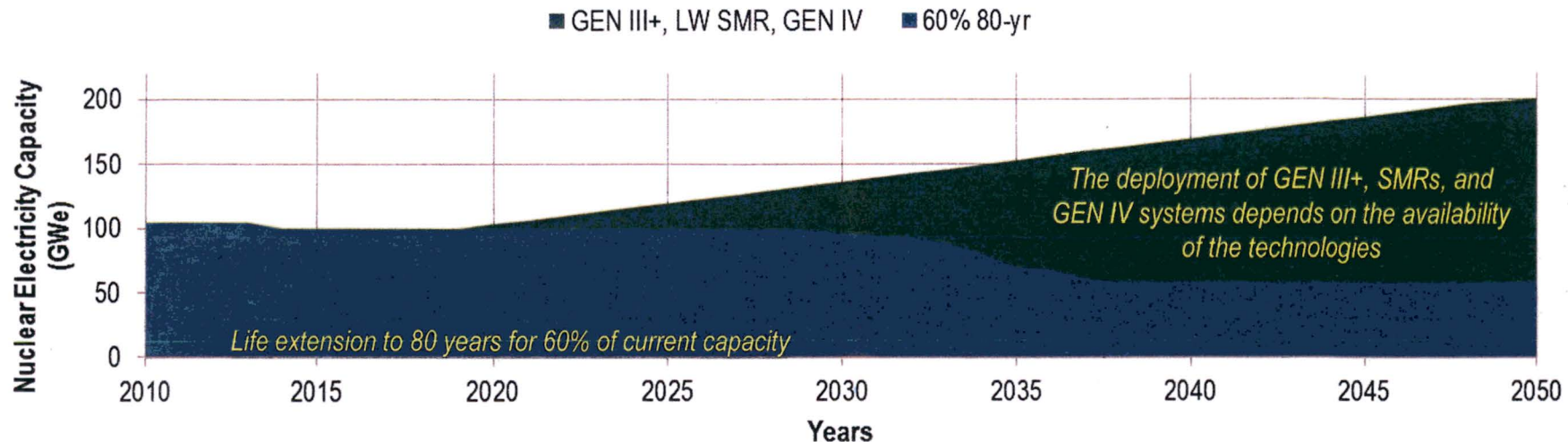
- Nuclear in a Clean Energy Future
- Gateway for Accelerated Innovation in Nuclear (GAIN)
- NE University Programs
- Nuclear Science User Facilities

A Clean Energy Future

- Achieving the vision of a clean energy future will require:
 - the continued long-term safe operation of the current fleet of commercial nuclear plants;
 - the commissioning of the next generation of Advanced LWRs currently under construction;
 - the deployment of new nuclear plants
 - Gen III+ Advanced LWRs
 - Small Modular Reactors
 - Gen IV Advanced Reactors
 - the utilization of nuclear in hybrid systems for non-traditional energy products;
 - a fundamental change in how nuclear technologies are perceived by the public; developed, licensed, and deployed by industry; and regulated by government
 - develop solutions for the long-term, sustainable management of our nation's spent nuclear fuel and high-level radioactive waste.



Nuclear Deployment & Clean Energy Goals



NE Support of US Industry Research and Development

Gateway for Accelerated Innovation in Nuclear (GAIN)

- Provides the nuclear community with access to the technical, regulatory, and financial support necessary to move advanced nuclear technologies toward commercialization while ensuring continued operation of the existing nuclear fleet.
- Integrates and facilitates efforts by private industry, universities and government researchers to test, develop and demonstrate advanced nuclear technologies.

Voucher Initiative

- DOE recently announced ~\$2 million in vouchers to assist small business applicants including entrepreneur-led start-ups seeking access to knowledge/capabilities available from DOE national labs so GAIN can support strong interest in nuclear energy by many new companies developing advanced nuclear energy technologies.

Energy Technology Commercialization Fund

- ~\$20 million allocation from DOE's applied RD&D and commercial application budget to pursue high impact commercialization activities. Established by Energy Policy Act of 2005. Provides matching funds with private partners to promote promising energy technologies for commercial purposes. (NE FY16 = \$4.3M)

SBIR/STTR

- NE provides over 3.4% of its applied RD&D funding annually to support small business research addressing focused NE mission areas. (NE FY17 est. \$13.6M)

Gateway for Accelerated Innovation in Nuclear



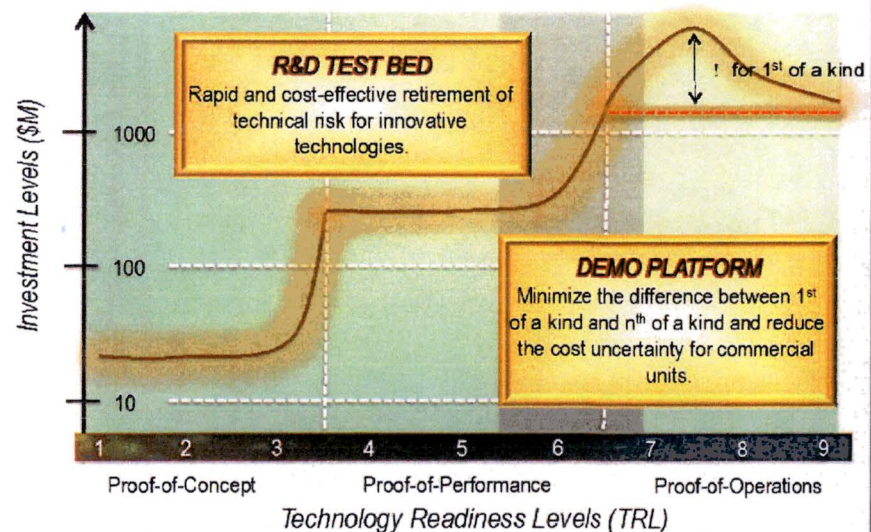
<i>Today's Challenges</i>	<i>DOE Response</i>	<i>GAIN Initiative</i>
<ul style="list-style-type: none"> • Time to market for nuclear technology is too long • Facilities needed to conduct RD&D activities are very expensive to develop and maintain • Facilities, expertise, materials, and historic data at government sites are not easily accessible to private sector • Technology readiness levels of innovative concepts vary and require different research and funding opportunities • Many technology developers require assistance working through the regulatory process for new nuclear technologies 	<ul style="list-style-type: none"> • Provide nuclear innovators and investors with a single point of access to the broad range of capabilities – people, facilities, materials, and data – across the DOE complex • Provide focused research opportunities and dedicated industry engagement • Expand cooperation with the Nuclear Regulatory Commission (NRC) to assist technology developers through the regulatory process 	<ul style="list-style-type: none"> • Integrated institute headquartered at INL and managing a nationally-distributed test-bed and demonstration platform • Dedicated to accelerate commercial readiness of innovative concepts • Collaborative approach to addressing barriers ✓ Public-Private Partnerships ✓ Technology-Centered Industry Working Groups • Task-specific R&D to advance technology



GAIN – A Nuclear Energy Innovation Test Bed

- Builds on and expands the successful Nuclear Science User Facilities model
- Fosters the rapid and cost-effective maturation of technologies towards engineering-scale demonstration for innovative nuclear technologies
- Enables the use of existing capabilities at multiple institutions in an integrated and “fast and cost-effective” manner
- Offers a wide range of flexible and re-configurable capabilities to address multiple technology needs
 - Irradiation, PIE, thermal-hydraulic loops, process development/testing, component fabrication/testing, etc.
- Includes predictive modeling and simulation capabilities to reduce the number of tests needed to optimize designs
- Incorporates a knowledge and validation center to provide easy and efficient access to existing data and legacy knowledge

TRL	Research Capabilities
1 - 3	Nuclear Science User Facilities
4 - 7	Nuclear Energy Innovation Test Bed



A tailored approach to support technologies of varying TRLs

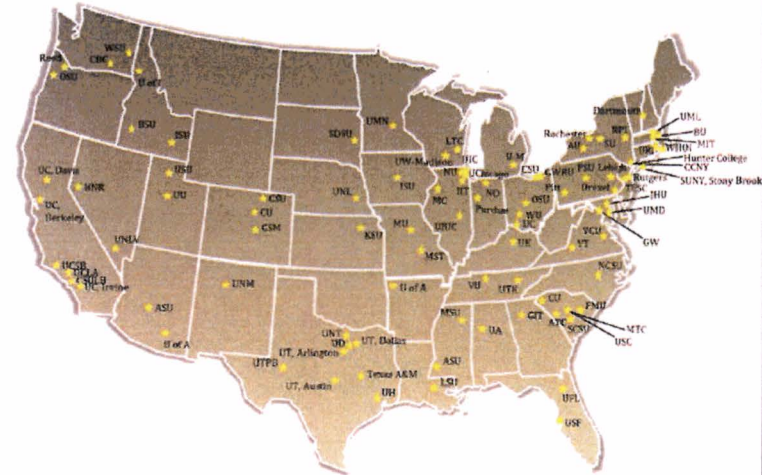
Initial Steps Towards Internationalizing GAIN

- DOE's Nuclear Science User Facilities (NSUF) is finalizing a CRADA with the Belgian Nuclear Research Centre (SCK-CEN) covering 4 near-term irradiation experiments in SCK-CEN's BR-2 test reactor.
- DOE is developing a MOU with the Belgian Nuclear Research Centre (SCK-CEN) to allow joint R&D access to the ATR in Idaho and the SCK-CEN's BR-2 test reactor.
- NE has asked our Nuclear Energy Advisory Committee (NEAC) to initiate a review of the availability of nuclear energy R&D capabilities internationally which could complement existing U.S. capabilities or bridge a gap in U.S. capabilities.

NE's University Programs

- Nuclear Energy University Program (NEUP)
 - NE designates up to 20 percent of the funds appropriated to its R&D programs to R&D and infrastructure projects awarded through an open, competitive solicitation process
- Integrated University Program (IUP)
 - NE provides graduate-level fellowships and undergraduate-level scholarships through an open, competitive solicitation process to support nuclear science and engineering education
- Research Reactor Infrastructure (RRI)
 - NE supports the continued operation of U.S. university research reactors by providing fuel services and maintenance of fuel fabrication equipment
- Traineeships
 - NE awards grants to competitively selected universities to train graduate level students in specific disciplines aligned with Department of Energy workforce needs

Since FY09, NEUP and IUP have awarded \$401 million to 104 schools in 39 states and the District of Columbia.



NEUP and IUP have a well established competitive process for awarding R&D, infrastructure, traineeships and scholarships /fellowships.

- FY2016 NEUP awards: 67 projects totaling \$61M for IRP, R&D, Infrastructure, and traineeship awards.
- FY2016 IUP awards: 57 scholarships and 33 fellowships, totaling \$5.0 M

Nuclear Science User Facilities (NSUF)

Provides the research community a means to conduct cutting-edge nuclear energy R&D by providing access to unique irradiation and post-irradiation examination capabilities, located at Idaho National Laboratory and various partner facilities.

- Reactor Facilities

- INL Advanced Test Reactor
- MIT Reactor
- North Carolina State University (NCSU) PULSTAR Reactor
- ORNL High Flux Isotope Reactor

- Beamline Facilities

- University of Wisconsin
- Illinois Institute of Technology
- University of Michigan
- NCSU PULSTAR Reactor

- Post Irradiation Examination

- Idaho National Laboratory (INL)
- North Carolina State University
- University of Wisconsin
- University of Michigan
- University of California Berkeley
- University of Nevada, Las Vegas
- Purdue University
- Pacific Northwest National Laboratory
- Oak Ridge National Laboratory (ORNL)
- Westinghouse

Summary

- Recognition of importance of nuclear – today and in the future – in meeting carbon reduction/climate goals
- Concern about financial viability of some currently operating plants, yet large carbon reduction benefits from keeping them running
- Increased interest in nuclear in some domestic and international markets
 - Gen III+
 - SMR technology
- Innovators, some utilities looking at advanced “Gen IV” nuclear as a way to move nuclear beyond electricity
 - Innovators need timely, affordable access to existing and new DOE capabilities



U.S. DEPARTMENT OF
ENERGY



Advanced Fuels Campaign

Update on U.S. Accident Tolerant Fuel Program

Nuclear Regulatory Commission Briefing

Office of Nuclear Energy

Jon Carmack

National Technical Director

Idaho National Laboratory

February 9, 2016

In the U.S. in the Fall of 2011 – The Public asked for “Meltdown Resistant Fuel”

In the Consolidated Appropriations Act, 2012, Conference Report 112-75, the Department of Energy, Office of Nuclear Energy was:

- Directed “to give priority to developing enhanced fuels and cladding for light water reactors to improve safety in the event of accidents in the reactor or spent fuel pools,”
- Urged “ that special technical emphasis and funding priority be given to activities aimed at the development and near-term qualification of meltdown-resistant, accident-tolerant nuclear fuels that would enhance the safety of present and future generations of Light Water Reactors,
- And requested “to report to the Committee, within 90 days of enactment of this act, on its plan for development of **meltdown resistant** fuels leading to reactor testing and utilization by **2020**.”

Engineers Defined Accident Tolerant Fuel Attributes and Metrics - Enhanced “Grace Time” or “Coping Time”

Fuels with **enhanced accident tolerance** are those that, in comparison with the standard UO_2 – Zr system, can **tolerate loss of active cooling** in the core for a **considerably longer time period** (depending on the LWR system and accident scenario) while maintaining or improving the fuel performance during normal operations.

Improved Reaction Kinetics with Steam

- Decreased heat of oxidation
- Lower oxidation rate
- Reduced hydrogen production (or other combustible gases)
- Reduced hydrogen embrittlement of cladding

Improved Fuel Properties

- Lower fuel operating temperatures
- Minimized cladding internal oxidation
- Minimized fuel relocation/dispersion
- Higher fuel melt temperature

Enhanced Tolerance to Loss of Active Core Cooling

Improved Cladding Properties

- Resilience to clad fracture
- Robust geometric stability
- Thermal shock resistance
- Higher cladding melt temperature
- Minimized fuel - cladding interactions

Enhanced Retention of Fission Products

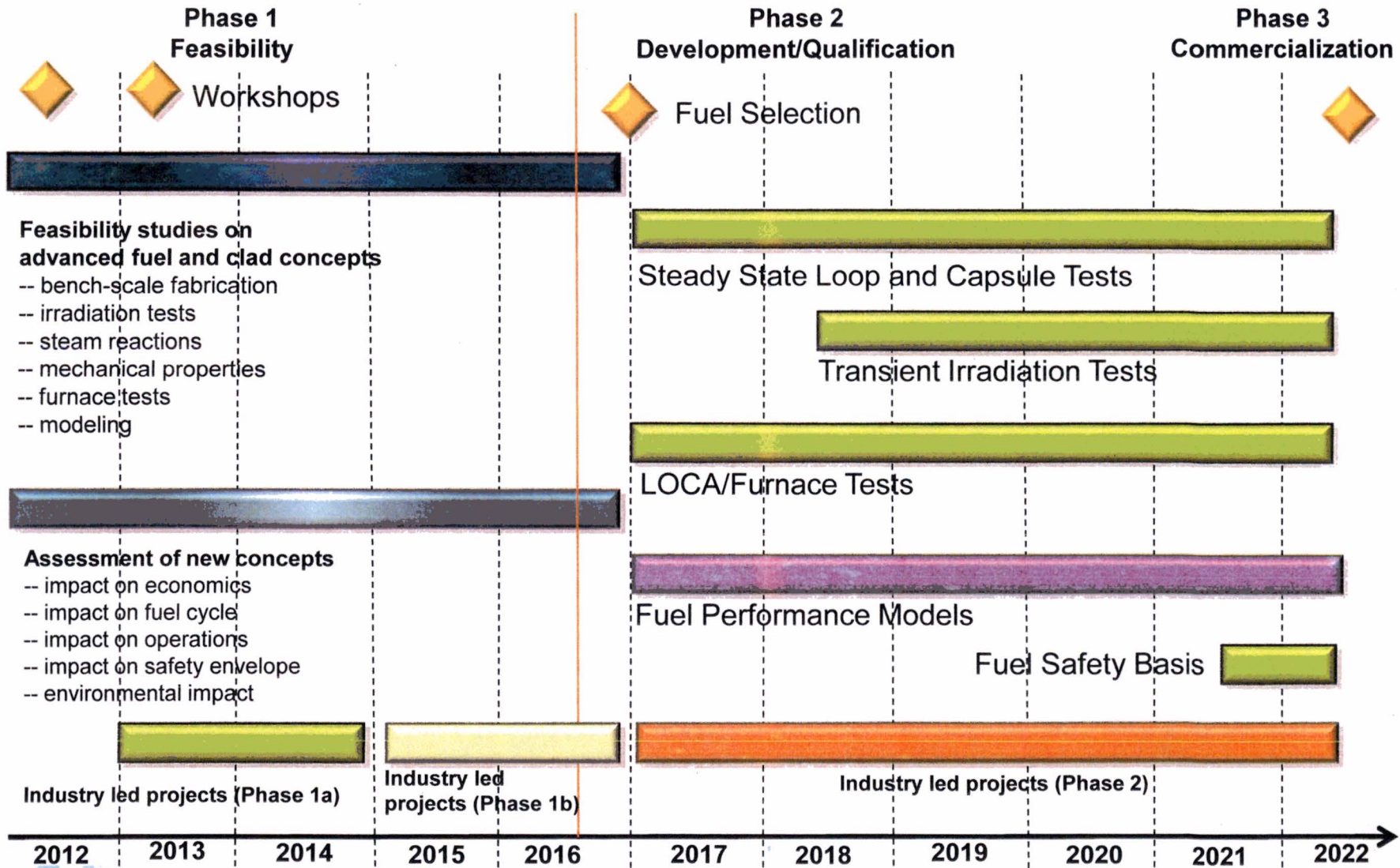
- Gaseous fission products
- Solid/liquid fission products

Major Goal of the OECD EATFWG in the International Community



Advanced Fuels Campaign

RD&D Strategy For Enhanced Accident Tolerant Fuels – 10 Year Goal

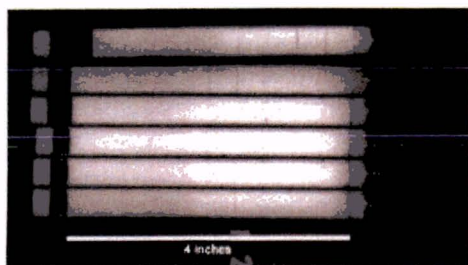
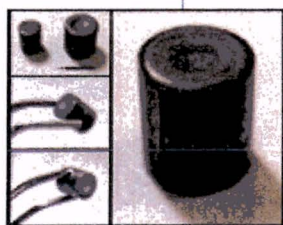


Advanced Fuels Campaign

U.S. DOE-Supported Industry Teams Will Complete Phase 1 in September of 2016

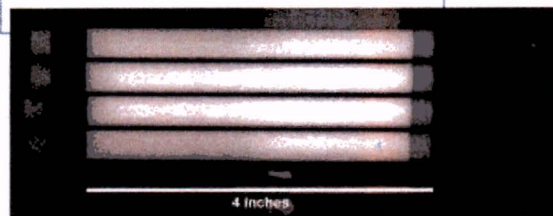
AREVA

- Cr coated Zr
- SiC-SiCf
- Increased fuel performance and thermal conductivity
- Additives
 - SiC powder or whiskers
 - Diamond
 - Chromia dopant



GE

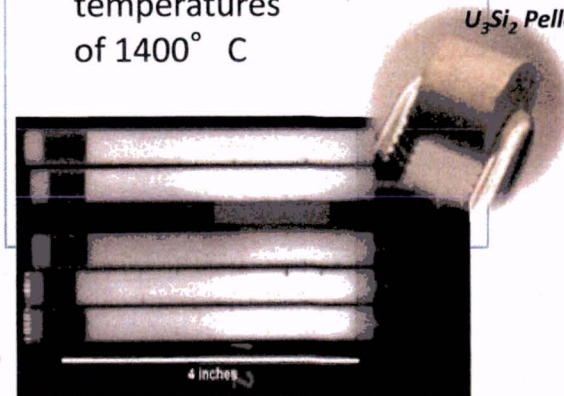
- Develop advanced **ferritic/martensitic steel alloys (e.g., Fe-Cr-Al)** for fuel cladding to improve behavior under severe accident scenarios
- Objectives:
 - Characterize candidate steels
 - Study tube fabrication methods, neutronics, fuel economy, thermo-hydraulic calculations, regulatory approval path
 - Initiate ATR testing with UO_2 and two cladding materials.



Westinghouse

- **Cladding** concepts:
 - SiC and SiC ceramic matrix composites;
 - coated Zr alloys
- **High density/high thermal conductivity fuel pellets**
- First batch of U_3Si_2 pellets were sintered using finely ground powder
- Pellets were pressed using pressures of 6,000-10,000 psi and sintered at temperatures of 1400°C

U_3Si_2 Pellet



Looking Forward to Phase II

- We will transition into Phase II of the DOE ATF program in Oct 2016.
- Recently, utility representatives asking for Accident Tolerant Fuel technology that can:
 - 1. Provide impactful coping time for the current fleet
 - 2. Make GENII reactors on par with GENIII+ designs that provide coping time before operator actions are required.
- To take full advantage of ATF technologies, all core and reactor components need to be considered.



Collaboration between the U.S. Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE)

**Victor McCree, Executive Director
for Operations, NRC
June 20, 2016**

Agenda

- **Advanced Non-light Water Reactors and Small Modular Reactors – Jennifer Uhle, NRO**
- **Subsequent License Renewal – Bill Dean, NRR**
- **Nuclear Safety Research and Educational Grants, Michael Weber, RES**

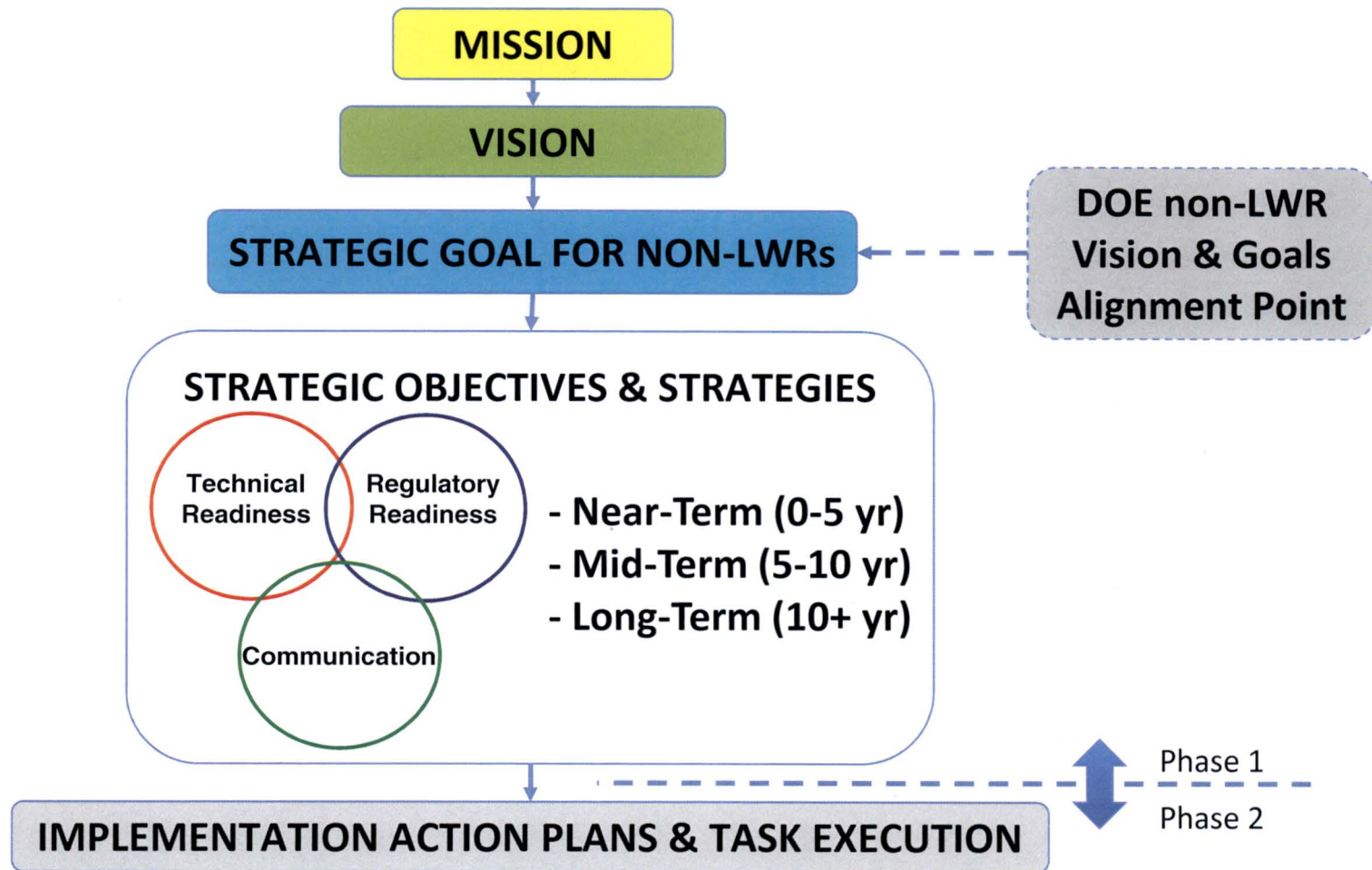


Activities and Planning Efforts for Advanced Non-Light Water Reactors and Small Modular Reactors

June 20, 2016

**Jennifer Uhle, Director
Office of New Reactors**

NRC Enhancing Readiness to Review Non-LWR Applications

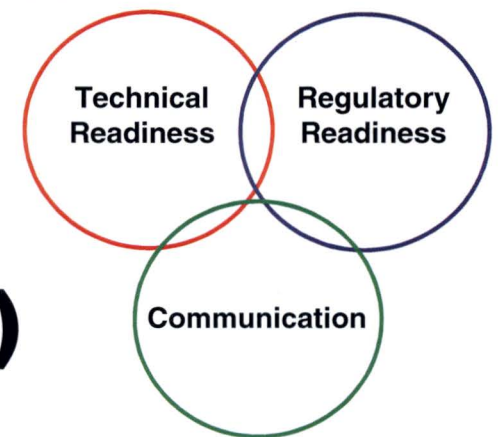


NRC and DOE Have Complementary Goals

- **DOE supporting deployment of two non-LWRs by 2030**
- **NRC vision and strategy supports NRC review readiness by 2025**

NRC Has Three Pronged Approach

- **Enhance technical readiness**
- **Optimize regulatory readiness**
- **Optimize communication**
 - **Near-term (0-5 years)**
 - **Mid-term (5-10 years)**
 - **Long-term (10+ years)**



NRC Developing Implementation Action Plans

- **Development of IAPs will include:**
 - **Identification of detailed tasks to be performed**
 - **Preparation of cost estimates**
 - **Estimated work durations**
 - **Expected participants by organization**

Successful Collaboration with DOE

- **Vision and Strategy documents are complementary**
- **Joint initiative to address the regulatory framework**
 - **Advanced Reactor Design Criteria**
 - **Policy issue resolution**
- **Effective public outreach**










What is the Status of NRC Readiness?

- **NRC regulatory and licensing process could support a non-LWR review today**
- **Enhancing efficiency and predictability of the regulatory process and technical readiness**
- **Pace commensurate with industry plans and readiness**

Small Modular Reactors Are Becoming A Reality

Applicant	Application	Submittal Timeframe
TVA Clinch River	Early Site Permit	May 2016
NuScale	Design Certification	November or December 2016
UAMPS	Combined License	End 1 st Qtr CY 2018
TVA Clinch River	Combined License	Mid-2018

Resolution of Key Policy Issues Proceeding

Issue	No Further Action	Path Forward
Prototype Reactors		
Licensing of Multi-Module Facilities		
Manufacturing License		
Defense-In-Depth		
Key Design Issues		
Control Room Staffing		
Operational Programs		
Installation During Construction		
Facilities Using Process Heat		

Resolution of Key Policy Issues Proceeding (Cont.)

Issue	No Further Action	Path Forward
Security and Safeguards	✓	
Aircraft Impact	✓	
Decommissioning Funding	✓	
SMR Variable Annual Fees	✓	Final Rule published May 24, 2016
Multi-Module Risk		Revising SRP Ch. 19
Mechanistic Source Term		SECY-16-0012 with Commission
Emergency Preparedness		Proceeding with Rulemaking
Insurance and Liability		Future Rulemaking, If Needed

Emphasizing Efficient, Safety-Focused Review

- **Finalizing Design-Specific Review Standard Sections**
- **Developing Safety-Focused Review Process**
- **Emphasizing Quality of Staff Information Requests**
- **Stressing Familiarity with Design**

Enhanced Safety-Focused Review Builds on Risk-Insights



NRO Emphasizing Review Readiness

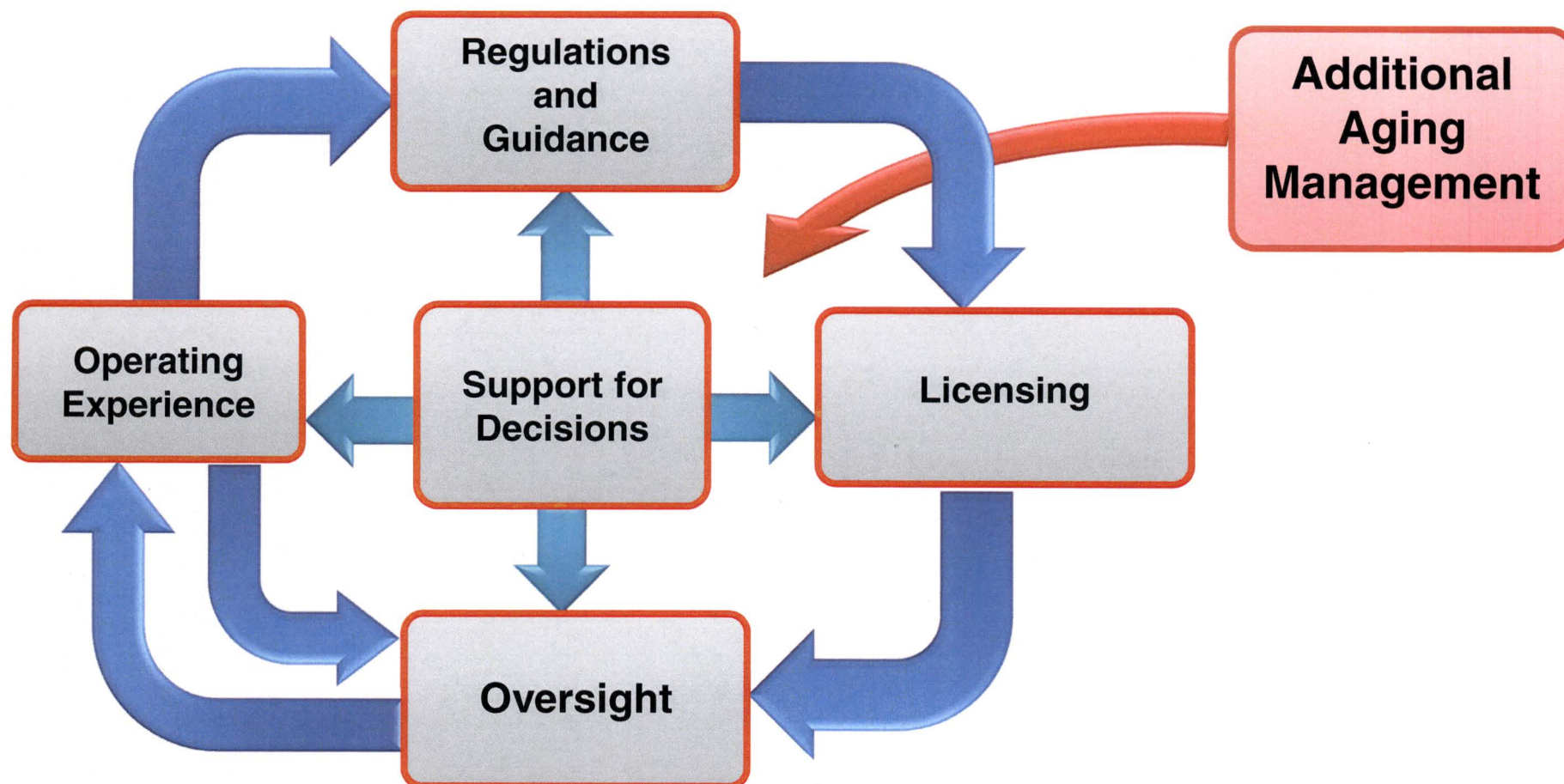
- **Vision and Strategy for Advanced Reactors Ready to be Implemented**
- **Efficient, Safety-Focused SMR Review Process Being Developed**
- **Preparations for SMR Reviews Coming to Timely Conclusion**



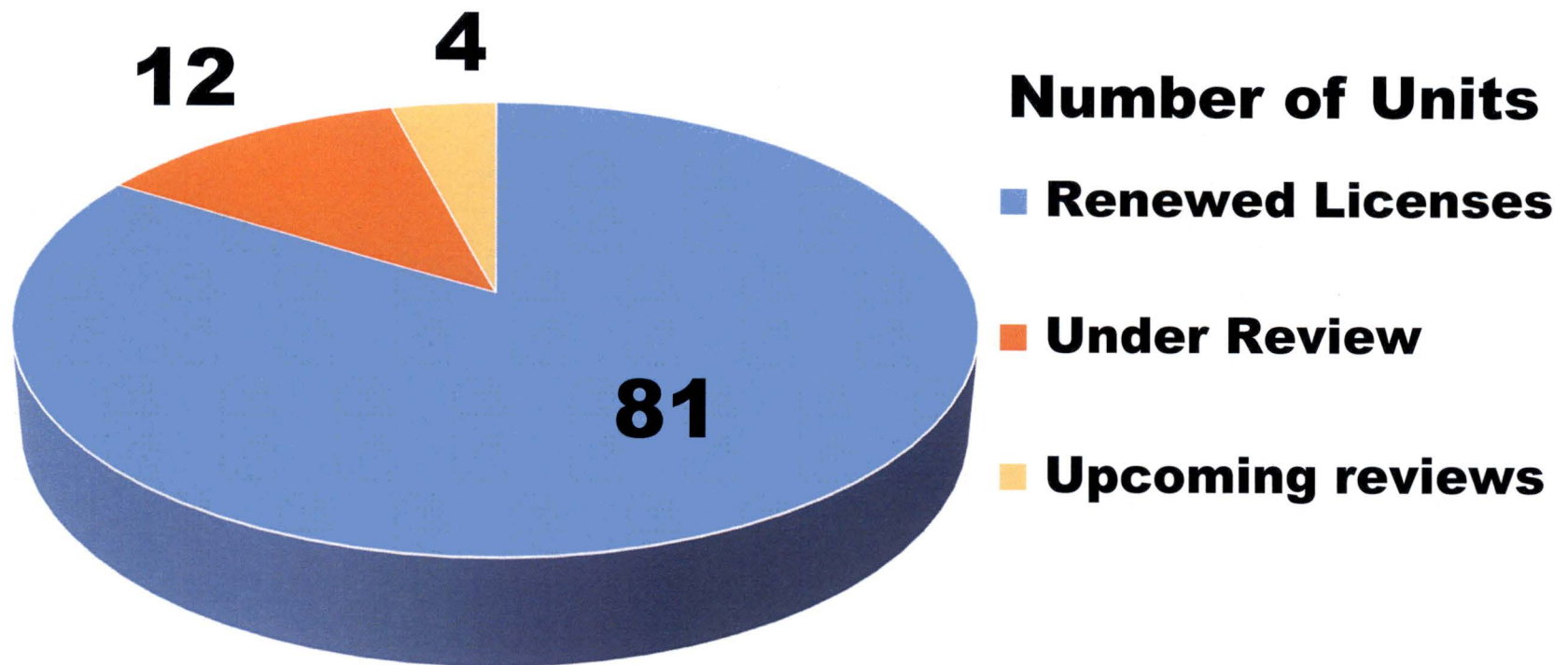
Subsequent License Renewal

June 20, 2016
Bill Dean, Director
**Office of Nuclear Reactor
Regulation**

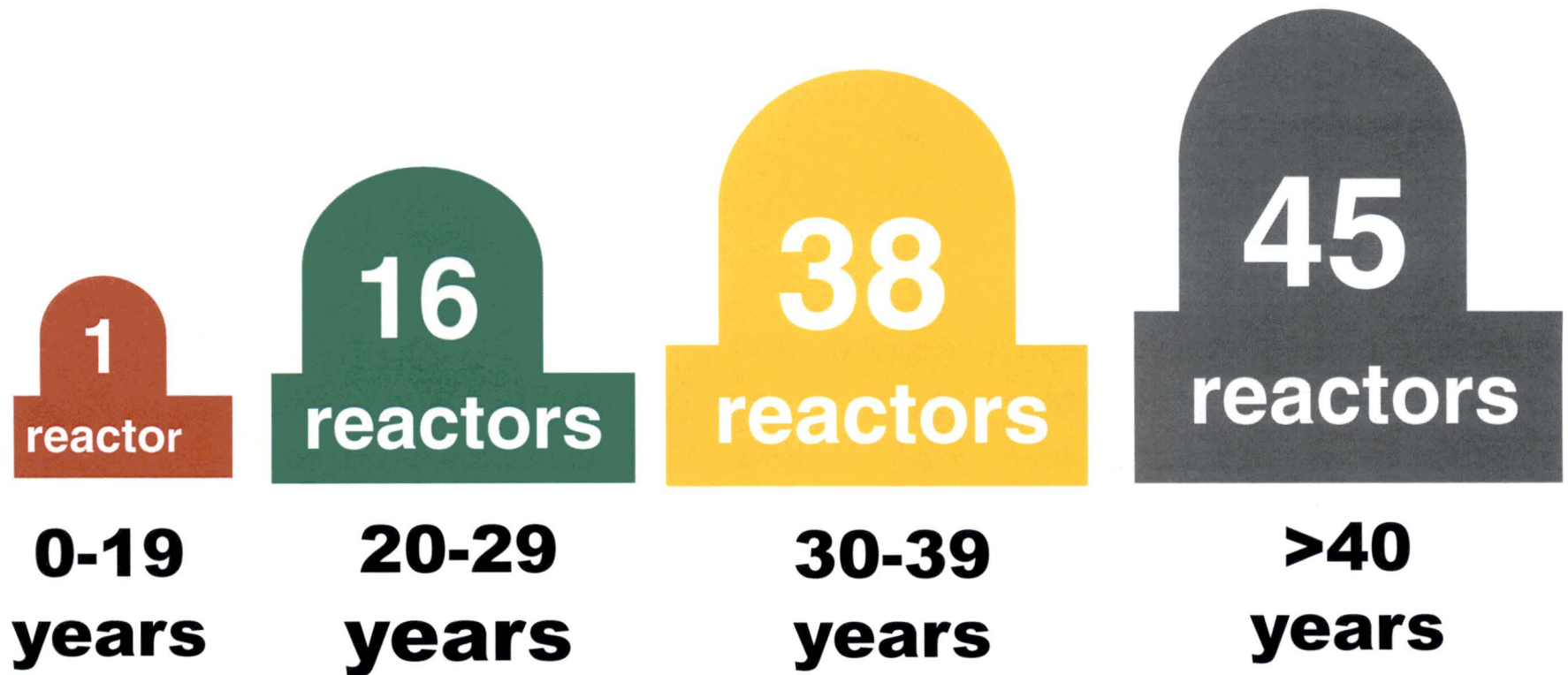
License Renewal Principles Build on Existing Regulatory Process



Most Plants Have Renewed Their Licenses



U.S. Commercial Nuclear Power Reactors: Years of Operation by the End of 2016



Achieving Safety Beyond 60 Years

- **The principles of license renewal would continue to be effective to ensure safety**
- **Optimization of application review process**
- **Technical reviews ensure effective aging management**

Four Key Technical Issues for Operations Beyond 60 Years

- **Reactor embrittlement**
- **Aging of reactor internals**
- **Concrete and containment degradation**
- **Electrical cable aging**

NRC Is Developing SLR Regulatory Guidance

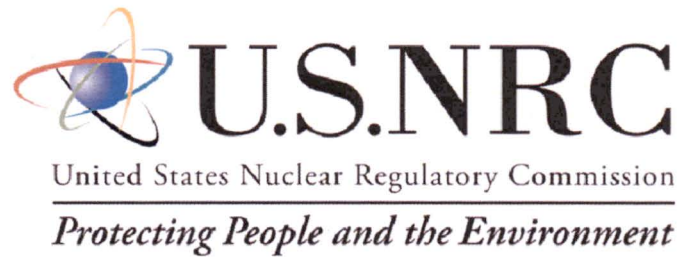
- **Draft GALL-SLR Report and SRP-SLR guidance issued in December 2015 for public comment**
- **Staff currently addressing public comments**
- **Final guidance expected to be issued in July 2017**

NRC Has Issued Interim Staff Guidance for License Renewal

- **Buried and underground piping and tanks**
- **Internal coating/linings**
- **Reactor vessel internals**
- **Steam generators**
- **Stainless steel structures in treated borated water**

Beginning Preparations for Licensing Accident Tolerant Fuels

- **Substantial research remains**
- **DOE and industry selection of candidate designs**
- **Licensing effort depends on departure from existing designs**
- **10 CFR 50.46c provides an appropriate regulatory framework**



Enhancing Nuclear Safety through Research and Educational Grants

June 20, 2016

**Mike Weber, Director
Nuclear Regulatory Research**

Collaboration Topics

- **Ensuring Safety for Subsequent License Renewal (SLR)**
- **Learning from Fukushima-Daiichi**
- **Reviewing Accident Tolerant Fuels**
- **Issuing Educational Grants**

Ensuring Long-Term Safety

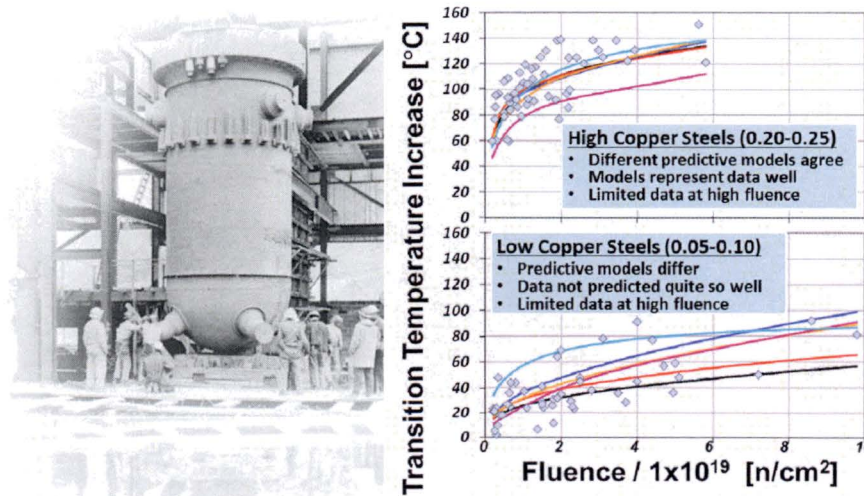
- **Materials degradation phenomena**
- **Light Water Reactor Sustainability program (LWRS)**
- **Expanded Materials Degradation Assessment**



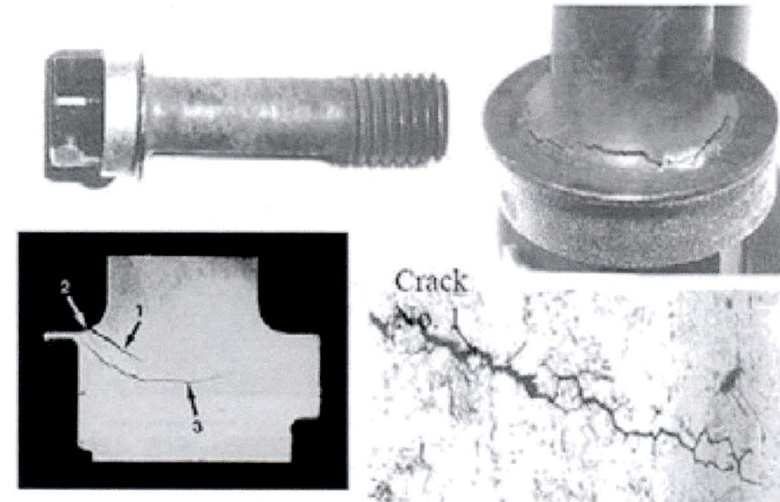
Concrete coring to obtain samples for evaluating effects of aging and environmental stressors

Resolving Degradation Issues

Reactor Pressure Vessel Embrittlement



Vessel Internals Cracking in a PWR Baffle Bolts



Alkali-Silica Reaction in Concrete Thermal Aging of Jacketed Cables

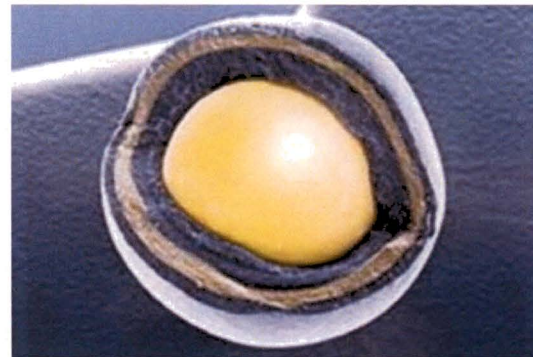


Learning from Fukushima-Daiichi

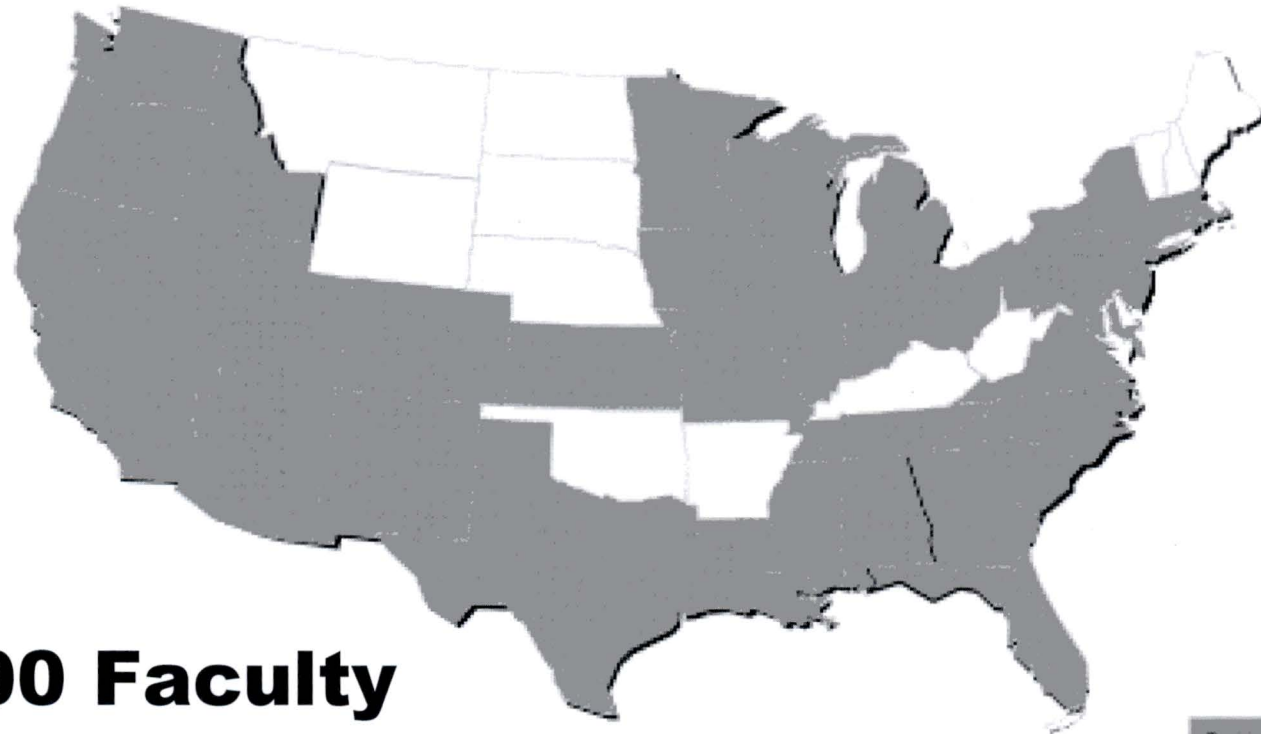
- **Benchmark Study of the Accident at the Fukushima (BSAF)**
- **Senior Expert Group on Safety Research Opportunities Post-Fukushima (SAREF)**
- **U.S.-Japan Civil Nuclear Energy Research and Development Working Group (CNWG)**

Reviewing Accident Tolerant Fuel

- **Advanced Fuel Campaign (AFC) update meetings**
- **Halden Reactor Project (HRP) Program Review Group meetings**
- **Accident Tolerant Fuel (ATF) Working Group**



Developing the Workforce



- **≥ 100 Faculty**
- **≥ 2700 Students**

**NRC Grants Program
Integrated University Program**

Acronyms

- **AFC: Advanced Fuel Campaign**
- **ATF: Accident Tolerant Fuel**
- **BSAF: Benchmark Study of the Accident at the Fukushima**
- **CFR: Code of Federal Regulations**
- **CNWG: U.S.-Japan Civil Nuclear Energy Research and Development Working Group**
- **DCA: Design Certification Application**
- **DOE: Department of Energy**
- **ECCS: Emergency Core Cooling System**

Acronyms

- **GALL Report: Generic Aging Lessons Learned Report**
- **HRP: Halden Reactor Project**
- **IAP: Implementation Action Plan**
- **ISG: Interim Staff Guidance**
- **LTA: Lead Test Assembly**
- **LWRS: Light Water Reactor Sustainability**
- **Non-LWR: Non-Light Water Reactor**
- **NRC: Nuclear Regulatory Commission**
- **NRO: Office of New Reactors**

Acronyms

- **NRR: Office of Nuclear Reactor Regulation**
- **PEO: Period of Extended Operation**
- **RES: Office of Nuclear Regulatory Research**
- **SAREF: Senior Expert Group on Safety Research Opportunities Post-Fukushima**
- **SLR: Subsequent License Renewal**
- **SRP: Standard Review Plan**
- **TVA: Tennessee Valley Authority**
- **UAMPS: Utah Associated Municipal Power Systems**