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NRC Commissioner Briefing

DOE Light Water Reactor Sustainability (LWRS) Program

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Office of Nuclear Energy

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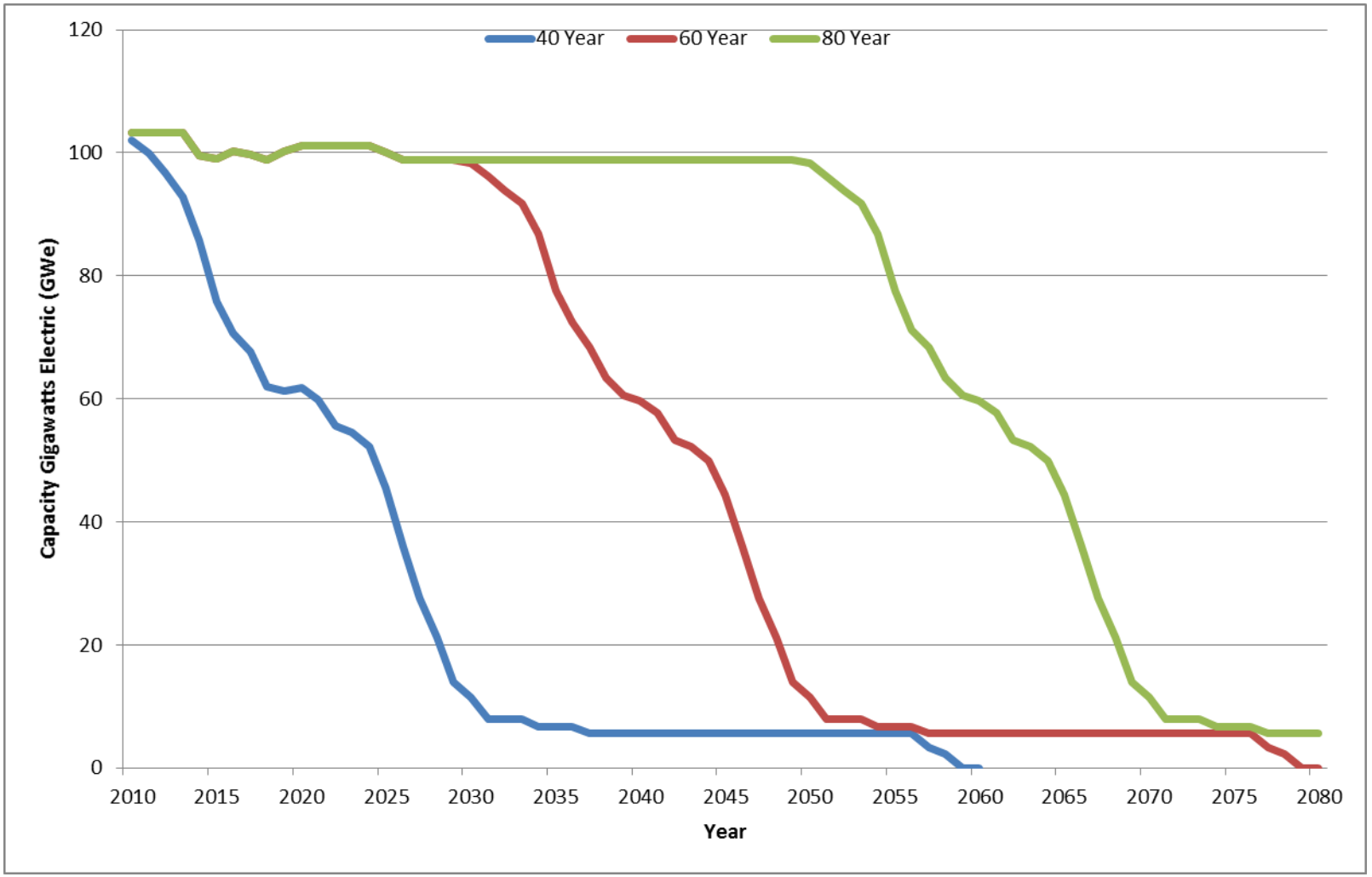
Projected Fleet Capacity



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LWRS Program

Objective:

- **Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors**

Four areas of research:

- **Materials Aging and Degradation**
- **Advanced Instrumentation, Information, and Control Systems Technologies**
- **Risk-Informed Safety Margin Characterization**
- **Reactor Safety Technologies**

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LWRS Program

DOE Role:

- **Support national strategic interests in energy security, reliability and grid stability**
- **Address fundamental scientific questions to make progress on broadly applicable technology issues**
- **Reduce technical uncertainties and risks such that industry is willing to make the necessary long-term investments**

Materials Research helps develop:

- **High quality materials degradation data**
- **An understanding of the underlying mechanisms**
- **Mechanistic models**
- **Improved monitoring capabilities**
- **Mitigation techniques**

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Materials Aging and Degradation

- **Expanded Materials Degradation Assessment (EMDA) (NUREG/CR-7153), a joint DOE/NRC sponsored effort published October 2014, captured status and knowledge gaps in the following four areas:**
  - Reactor Pressure Vessel (RPV) steels
  - Core internals and piping systems
  - Concrete civil structures
  - Electrical power and instrumentation and control (I&C) cables

- **Much progress has been made to fill knowledge gaps**
- **No generic technical show stoppers to long-term operation have been identified**
- **Research continues to improve understanding and reduce uncertainties**

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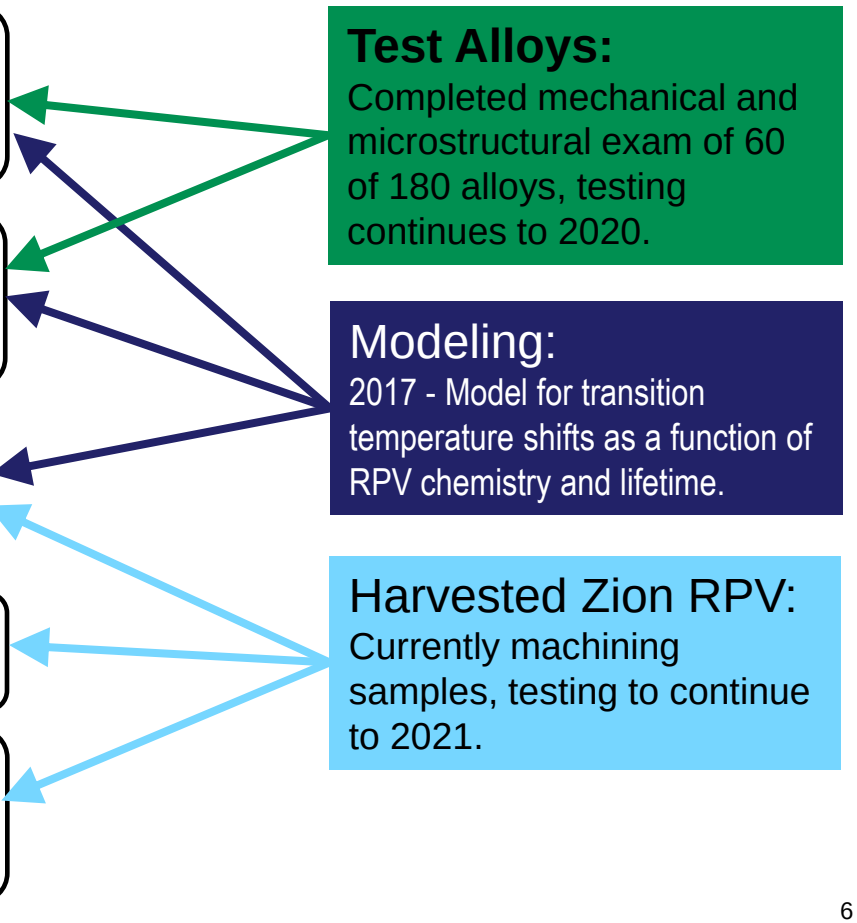
Reactor Pressure Vessels

Evaluation of risk for high fluence embrittlement and possible mitigation techniques through the mechanistic understanding the effects of……

- Fluence, flux and influence of alloy chemistry on materials performance
- Radiation-induced effects and mitigation techniques
- Neutron attenuation and variation in through thickness properties
- Aging / irradiation behavior of weldments
- Bias in toughness values derived from pre-cracked Charpy specimens



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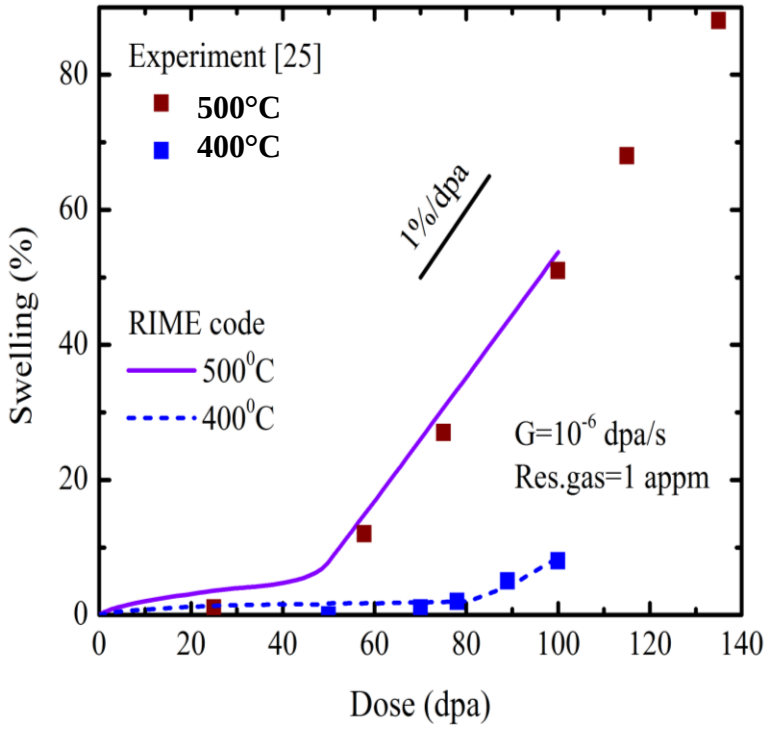
Core Internals

Research involves analysis and testing of core internal materials of both commercial and model alloys and includes service materials.

The goal is to develop physics based predictive models

- 2017 – Deliver Radiation Induce Microstructural Evolution (RIME) model for swelling
- 2017 – Complete an *integrated thermal and radiation* induced segregation model
- 2019 – Complete a predictive model for Irradiation-Assisted Stress Corrosion Cracking (IASCC)

These models can be used by industry to better predict, manage, and mitigate the degradation of core internals.



RIME code vs. experimental data

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Piping

Environmentally Assisted Fatigue

- Research has focused on experimental studies to develop a finite element based fatigue model that tracks key time-dependent properties for fatigue life based on LWR environmental conditions and plant operation history, rather than empirical methods using test data under non-relevant conditions.
- 2017 – Complete thermal fatigue models for a 508 Low Alloy Steel RPV and 316L alloy surge line pipe.

Thermal Aging of Cast Austenitic Stainless Steel (CASS) and Austenitic Stainless Steel Welds (ASSW)

- Research the effects of long-term thermal exposure on the service life of CASS and ASSW components.
- 2019 – Complete a validated predictive model.
- Future work – address synergistic effects of irradiation and thermal aged CASS materials.

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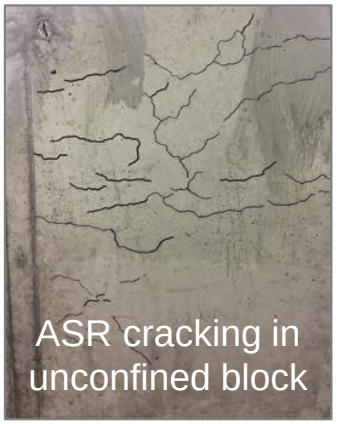
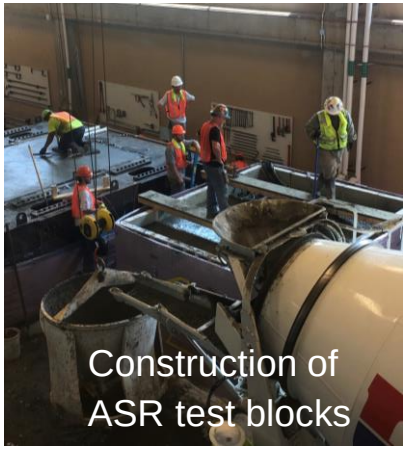
Concrete Civil Structures

Conducting research on the fundamental behavior of the heavily reinforced concrete found in nuclear power plants under the influence of irradiation and Alkali-Silica Reaction (ASR)

- Irradiation studies on mineral analogues, aggregates and concrete, with data retained in a developed database
- Conducting experiments on ASRs influence on the structural significance to large reinforced structures
- 2020 – Complete a model tool to predict the impact of both irradiation and ASR on concrete structural performance.


ASR cracking in unconfined block

Based on research to date and initial evaluations, concrete structures appear to have significant safety margins during the 60-80 year time period.


Construction of ASR test blocks

Concrete NDE

- Improved existing NDE techniques by using advanced signal processing techniques.

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Power and I&C Cables

Understanding cable degradation mechanisms and the ability to predict remaining useful life will help plants better manage the aging of their cables

- Research is being conducted on the typical cable types found at plants
- Accelerated aging under combined temperature and irradiation conditions
- Electrical, chemical, and mechanical characterization is performed to establish aging trends and key factors for cable condition monitoring
- Also evaluating and developing promising Non-Destructive Evaluation (NDE) methods and technologies through collaboration with vendors and industry

Current model development

- 2019 – complete a predictive models for cable aging under combined thermal and irradiation conditions

We believe the aging of plant cable during the 60 to 80 year period of operation can be reasonably managed with appropriate monitoring programs.

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Summary

- No generic technical show stoppers to long-term operation have been identified
- Supporting the development of improved monitoring techniques
- Inform industry Aging Management Programs