INL/MIS-24-77548-Revision-0

FY24 LWRS Program overview

April 2024

Jodi L Vollmer, Alexis Victor Basile David

Changing the World's Energy Future

Idaho National Laboratory

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

INL/MIS-24-77548-Revision-0

FY24 LWRS Program overview

Jodi L Vollmer, Alexis Victor Basile David

April 2024

Idaho National Laboratory
Idaho Falls, Idaho 83415

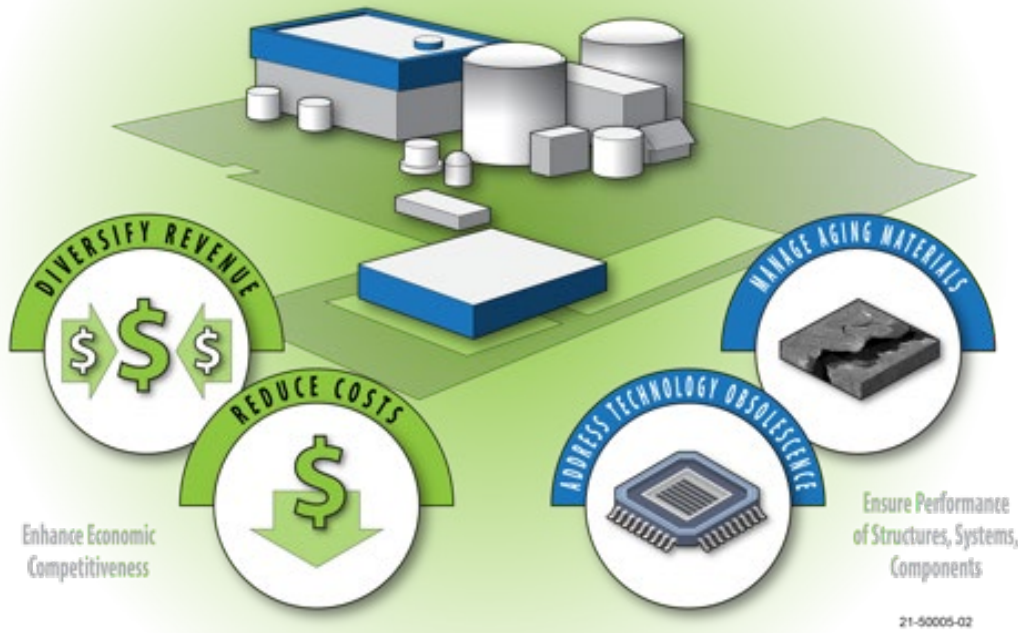
http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Light Water Reactor Sustainability Program

- Goal
  - Enhance the safe, efficient, and economical performance of our nation's nuclear fleet and extend the operating lifetimes of this reliable source of electricity.

- Objectives
  - Enable long term operation of the existing nuclear power plants.
  - Deploy innovative approaches to improve economics and economic competitiveness of light water reactors in the near term and in future energy markets.
  - Sustain safety, improve reliability, enhance economics.



LWRS Program Research Pathways

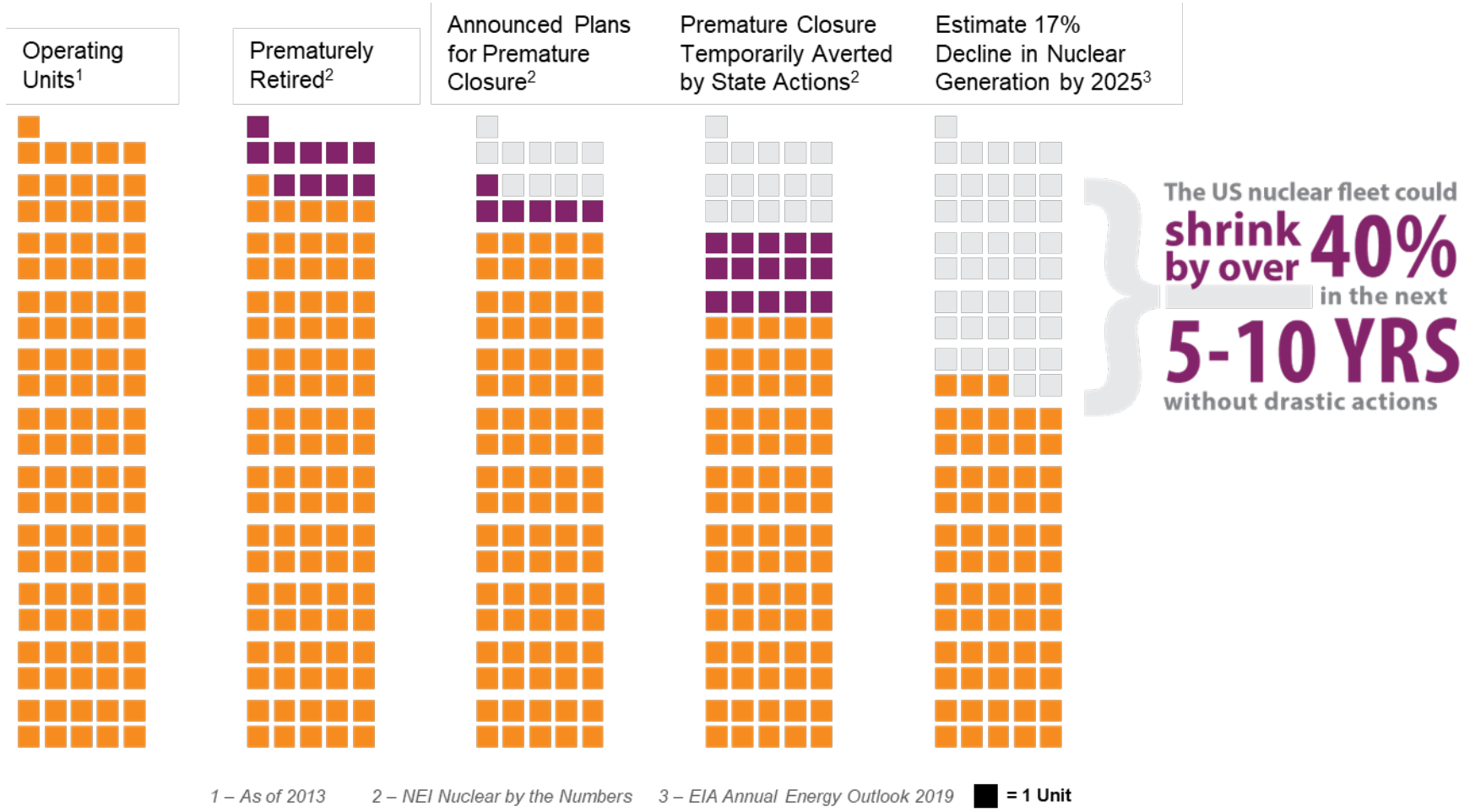
Plant Modernization	**Enable plant efficiency improvements** through a strategy for long-term modernization
Flexible Plant Operation and Generation	**Enable diversification** and increase revenue of light water reactors by extracting electrical and thermal energy to produce non-electrical products
Risk-Informed System Analysis	**Develop significantly improved safety analysis methods and tools** to optimize the safety, reliability, and economics of plants
Materials Research	**Understand and predict** long-term behavior of materials in nuclear power plants, including detecting and characterizing aging mechanisms
Physical Security	**Develop technologies** and the technical bases to optimize physical security postures to maintain protection and improve efficiencies

The Challenge

"These early retirements are noteworthy, since the cost to construct the reactors is sunk. Even in a market where building a new plant would be unprofitable, the continued operation of a well-maintained and operated plant might be expected to be profitable. A decision to close means the wholesale price of electricity does not even cover a plant's ongoing operating and maintenance costs, including any capital investments needed to keep the facility in safe working order."

MIT, The Future of Nuclear Power in a Carbon Constrained World

MIT – Massachusetts Institute of Technology
NEI – Nuclear Energy Institute
EIA – Energy Information Agency
US – United States



Plant Modernization

- Extend life and improve performance of existing nuclear power plant fleet through modernized technologies and improved processes for plant operation and power generation.

Long Term Management Of Plant Systems

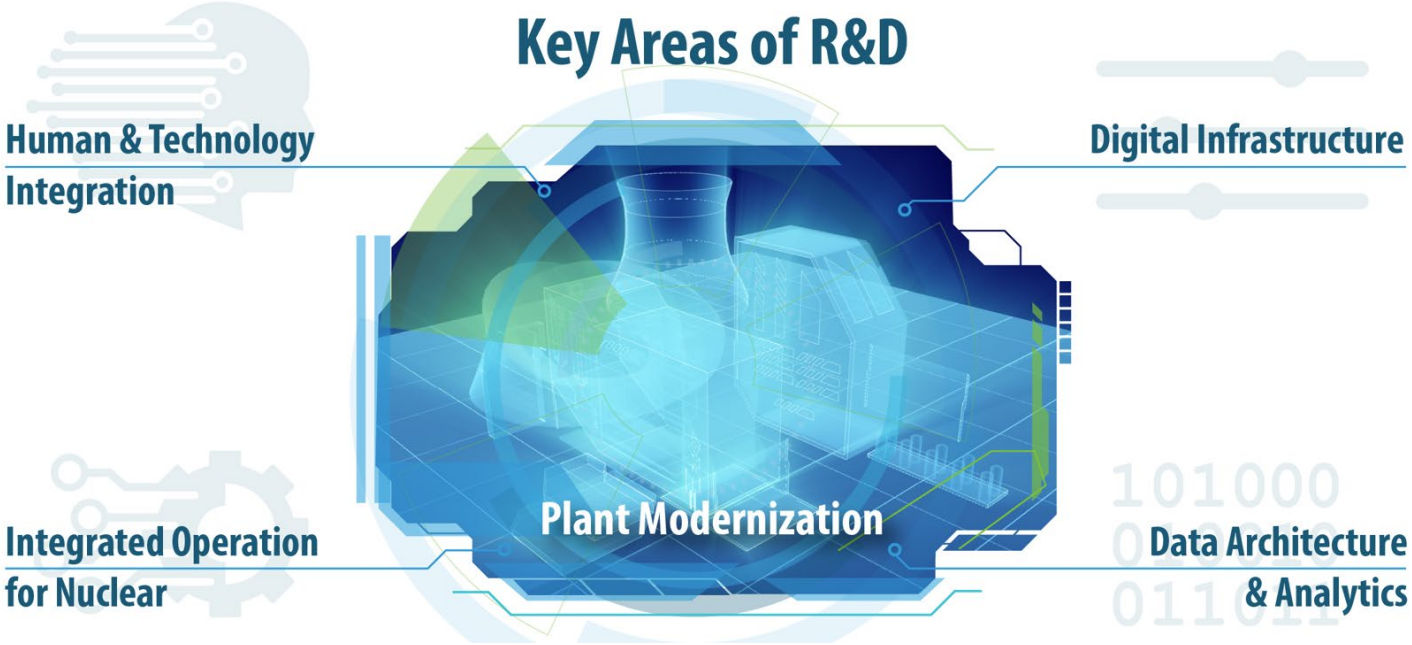
License Extension 60, 80, or 100 years

Nuclear Cost Competitiveness

Cost pressures from other generation sources

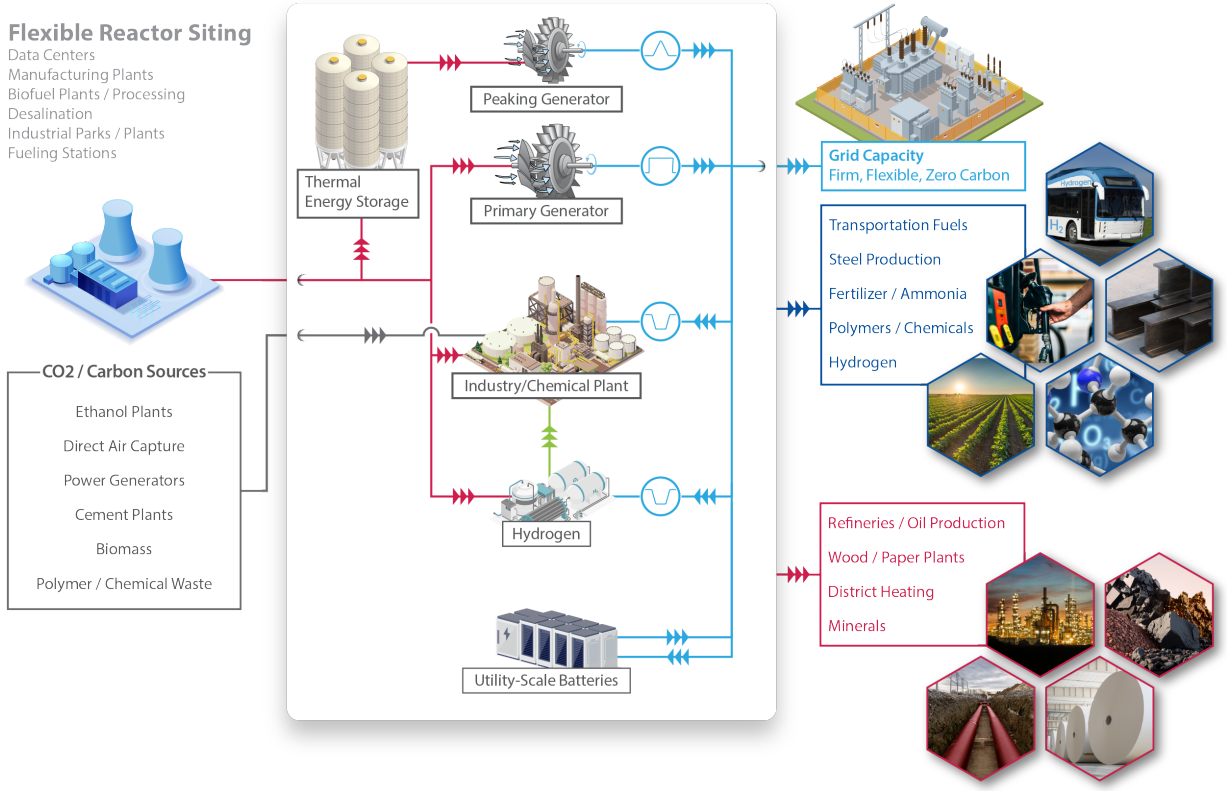
Worker Attraction and Retention

Worker interest in new technology



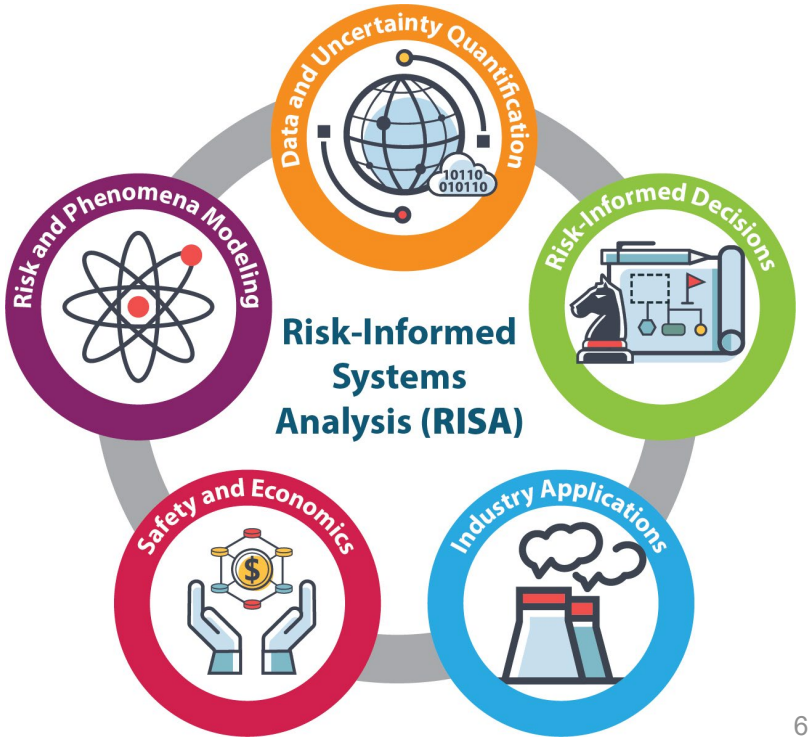
Flexible Plant Operation and Generation

- Develop and support the deployment of technologies to increase the flexibility of nuclear power plants operation and generation, by diversifying their products and revenue.
- Research areas:
  - Hydrogen production and storage (including safety)
  - New thermal extraction and delivery systems
  - Modifications to the electricity transmission station
  - Operator control of dynamic power dispatch
  - New communications between the grid operator and hydrogen plant allow plants to rapidly transition between the grid market and hydrogen production.



Risk-Informed Systems Analysis

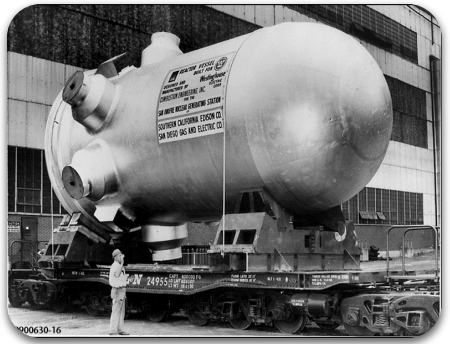
- Optimize safety margins and minimize uncertainties in nuclear power plants, to achieve economic efficiencies while maintaining high levels of safety.
  - Provides scientific basis to better represent safety margins and factors that contribute to cost and safety.
  - Develops new technologies that reduce operating costs.
- Research areas:
  - Advanced modeling of physics-based phenomena,
  - Advanced Data Analytics and Digital Modeling,
  - Probabilistic Risk Assessment, and
  - Human-Reliability Analysis.



Materials Research Pathway

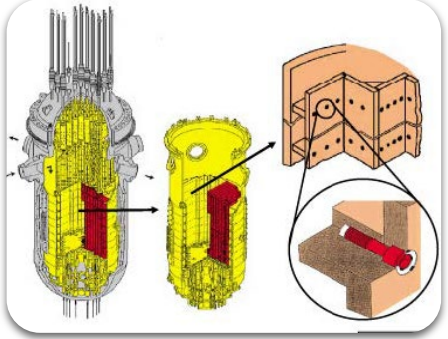
- Understand long-term environmental degradation behavior and create technologies for their its mitigation in key materials in nuclear power plants.
- Research areas:

Reactor Pressure Vessel



- Harvest high fluence A-60 Palisades surveillance capsule.
- Develop embrittlement trend curves.

Core internal and pressure boundary

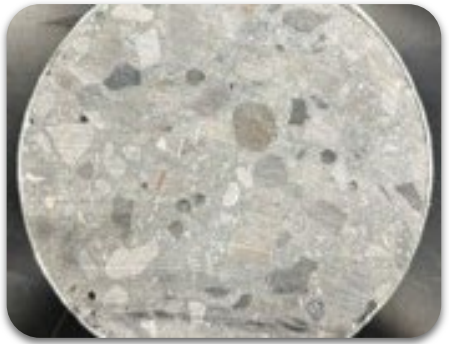


- Assess long-term thermal aging, weldment, stress corrosion cracking (SCC) of alloys and materials.

Mitigation

- Develop advanced welding technology, including laser and friction stir welding.

Concrete



- Develop capabilities to enable large concrete 3D simulations
- Methodologies for experimental and predictive assessment of irradiated concrete.

Cable

- Assess cables materials degradation.
- Thermal aging, ground fault and water detection.

Physical Security

- Create methods, tools, technologies and capabilities to optimize and modernize a nuclear facility's physical security posture.
  - Develop mitigation strategies and enhance the technical basis necessary for stakeholders to reevaluate physical security postures while meeting regulatory requirements.
  - Analyze the existing physical security regime, current best practices, and compare with alternative/modern methods (incl. advanced modeling and simulation).
- Research areas:
  - Advanced Security Technologies
  - Risk-Informed Physical Security
  - Advanced Security Sensor and Barrier Systems

Force-on-force exercise

Visualization for modeling remote operated weapon system placement