



**Light Water Reactor Sustainability (LWRS) FY  
2021 CINR Webinar: RC- 6,7,8,9,10**

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**Light Water Reactor Sustainability**

# Light Water Reactor Sustainability

- **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 LWRs in the near term and in future energy markets.
  - Sustain safety, improve reliability, enhance economics
- **Focus Areas**
  - Plant Modernization Research and Development
  - Flexible Plant Operation and Generation
  - Risk-Informed Systems Analysis
  - Materials Research
  - Physical Security



*Nine Mile Point - Courtesy Exelon*

# Research Pathways

## Plant Modernization

Enable plant efficiency improvements through a strategy for long-term modernization

## Flexible Plant Operation & Generation

Enable diversification and increase revenue of light water reactors by deploying systems to extract 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 and provide technologies and the technical bases to optimize physical security postures to maintain protection and improve efficiencies

# LWRS - Plant Modernization Research

Strategic Goal –Extend life and improve performance of existing fleet through modernized technologies and improved processes for plant operation and power generation

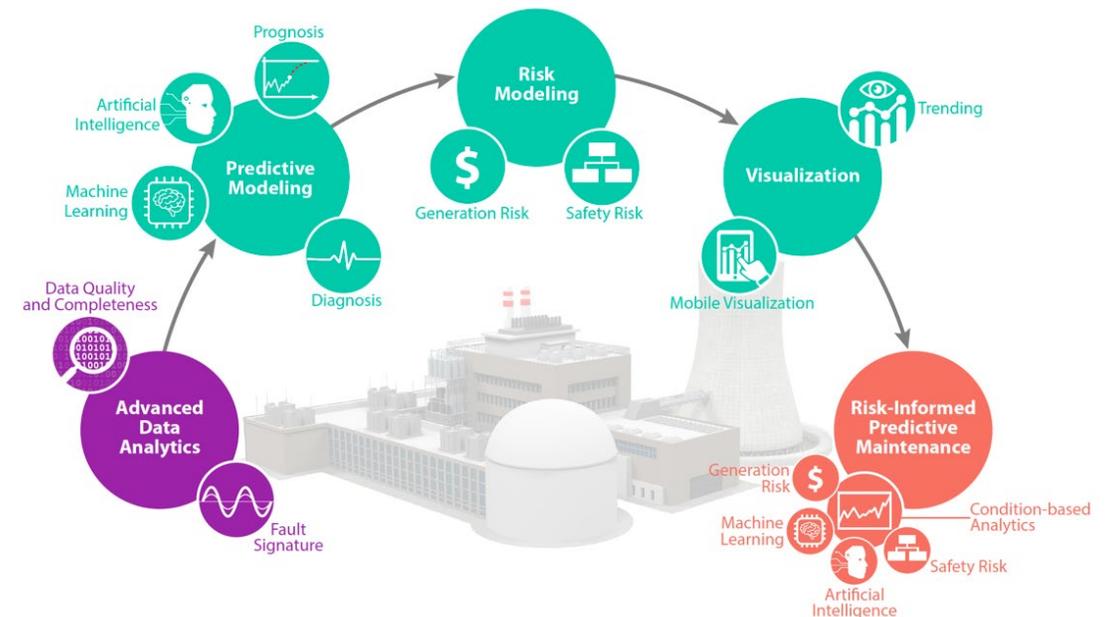
- Research Outcomes –Technologies and Results that significantly reduce the technical, financial, and regulatory risk of modernization
- Research Activities
  - Develop and demonstrate new digital instrumentation and control technologies and the means to enable significant improvements in operational efficiencies through their broad deployment
  - Develop new operational concepts that enable a transformation from labor centric to technology centric plant operation
- Research Outputs and Deliverables Include:
  - New technologies that enable modernization
  - Studies to enable the transition from current to future
  - End State Requirements Studies
  - Cost Benefit Studies
  - Technical Bases Studies
  - Implementation Recommendations & Lessons Learned
- Experience & Capabilities
  - Effective engagement with nuclear power industry
  - Coordinating industry efforts to achieve greatest impact



## • IMPROVING AUTOMATION USE IN NUCLEAR POWER PLANTS

– Research is sought to develop a methodology and provide the necessary evidence needed to verify automation technologies are explainable and trustworthy. This research needs to establish the technical bases and demonstrate automation technologies proposed for use in a nuclear power plant are operationally acceptable. Proposals should:

- Develop and demonstrate methods to ensure automation technologies being considered for deployment in commercial nuclear power plants are explainable and trustworthy.
- Develop and demonstrate the appropriate level of automation transparency to ensure automations reduces human workload, and improving overall system performance while maintaining the appropriate level of human situational awareness.

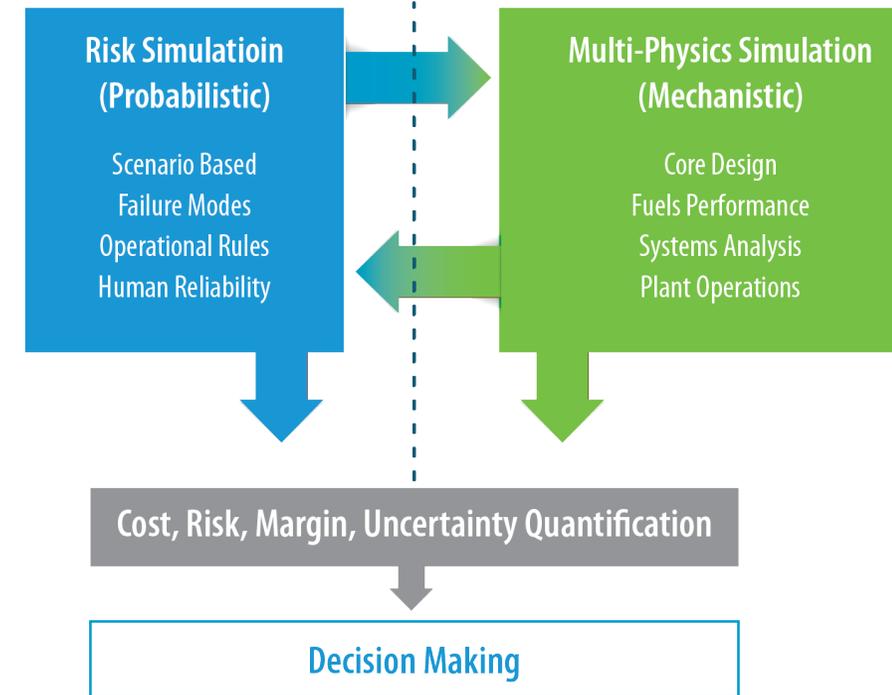


# LWRS - Risk-Informed Systems Analysis (RISA)

Strategic Goal – Optimize safety margins and minimize uncertainties to enhance safety & economic efficiencies

- Research **Outcomes** – develop & demonstrate methods & tools to enhance risk analysis opportunities for risk-informed applications.
- Research **Activities**
  - Develop and demonstrate enhanced analysis capabilities of LWR systems through advanced methods, tools, and data to enable risk-informed margins management.
  - Conduct risk-assessment pilot project applications with industry to employ risk-informed methods, tools, and data to reduce operating costs.
- Research **Products**
  - Risk assessment methods & tools developed & demonstrated via pilot applications available for industry adoption.
  - Data, technical bases, and lessons learned from pilot projects that can be promulgated and scaled across industry to improve plant efficiency, increase confidence in their use, and reduce operating costs.

## Risk-Informed Framework

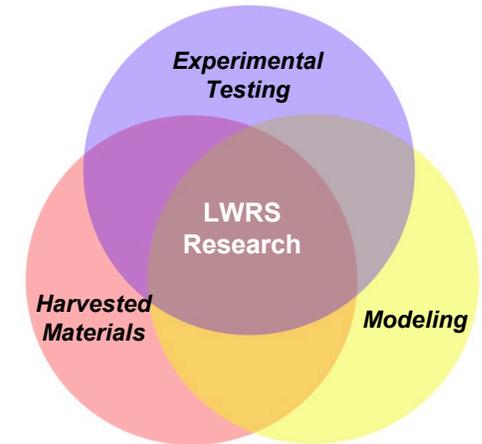


- **EXTENSION OF LEGACY PRA TOOLS TO ACCELERATE RISK-INFORMED APPLICATIONS FOR LWRS**
  - Technical issue areas to be considered for investigation include:
    - Quantification Speed when Supporting Decision Making
    - Integration of Multi-Hazard Models into Traditional PRAs
    - Acceptance Criteria for Model Detail Required in Various Risk-Informed Applications
    - Model Modification Simplification and Documentation Automation
    - Improving Models for Time-Dependent Approximations
  - The research of this call will be to develop and apply new approaches to legacy PRA tools and methods that will reduce modeling or analysis time, reduce costs associated with application of PRA, or will provide clearer understanding of the PRA model and its resulting insights for decision making. The resulting tools and methods modifications will be created to provide analysis benefits to the current LWRs fleet of plants. Proposals that address analysis methodology development across multiple technical issues are strongly encouraged.

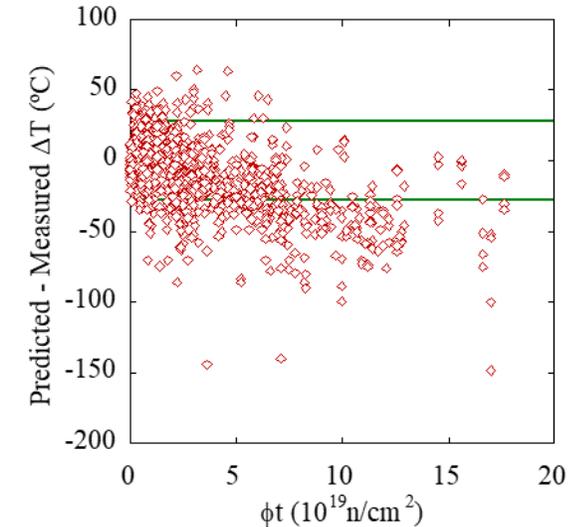
# LWRS - Materials Research

Strategic goal - To develop the scientific basis for understanding and predicting long-term behavior of materials in nuclear power plants and to provide data and methods to assess performance of systems, structures, and components essential to safe and economically sustainable nuclear power plant operations.

- The research outcomes from this program will be used by utilities, industry groups, and regulators to inform operational and regulatory requirements for materials in reactor systems, structures and components subjected to long-term operation conditions.
- Research activities include:
  - Studies of harvested materials and other materials studies to measure the effects of environmental and service conditions on key material properties.
  - Modeling and simulation to develop multi-scale Multiphysics models of material performance to predict behavior and reduce experimental burden for long-term studies.
  - Research and development of monitoring techniques used to characterize the performance of key service materials in core components, cabling, concrete and other systems needed during long term operation.
  - Research and development to understand, control, and mitigate materials degradation processes



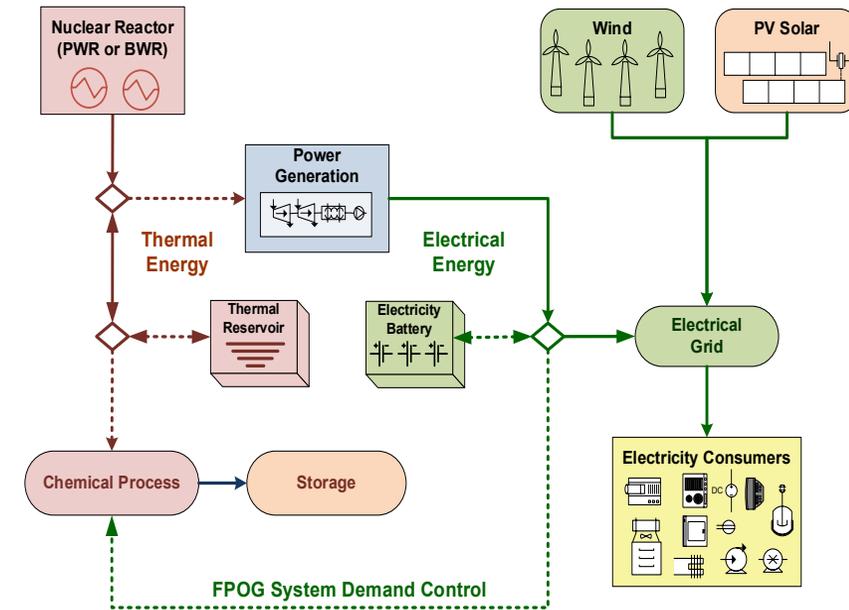
- **CHARACTERIZATION AND MODELING OF THE HIGH FLUENCE EFFECT ON REACTOR PRESSURE VESSEL STEELS**
  - Technical issue areas to be considered for investigation include:
    - Quantification Speed when Supporting Decision Making
    - Integration of Multi-Hazard Models into Traditional PRAs
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# LWRS – Flexible Plant Operation & Generation

Strategic Goal – to diversify revenue sources of plants in the U.S.

- Develop technical and economic approaches for commercial deployment of these systems and to help LWR owners implement and test the leading options.
- **Design and Economics:** Conduct technical and economic assessments to evaluate market opportunities for LWRs to supply electricity and steam or heat to produce non-electricity products.
- **Energy Dispatch:** Develop efficient electricity and thermal energy delivery systems and conduct human factors and control systems research needed to extract and deliver thermal energy from a plant for use by an industrial process.
- **Safety Assessments:** Ensure new concepts of operations remain within the operating basis of LWRs or to or assess changes needed to deliver thermal energy to an industrial user.

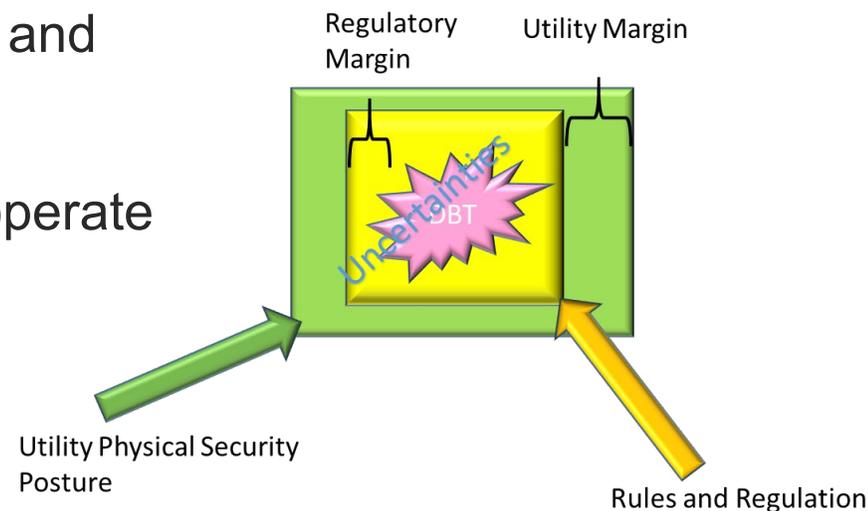


- **DEVELOPMENT OF THERMAL AND ELECTRIC POWER DISPATCH SIMULATION TOOLS**
  - Suggestions for development of the BWR simulator tools include:
    - Rancor Microworld simulators that are suitable for operator-in-the-loop and hardware-in-the-loop studies to investigate human factors issues associated with specific pilot-scale test capabilities
    - High-fidelity, full-scope BWR simulators that include different BWR plant types coupled to different industrial plants, such as simplified hydrogen, fertilizer, petrochemical, or steel production plants.
    - RELAP5-3D models of the coupled processes to verify system thermal-hydraulic performance predictions.
  - Studies should incorporate information that has already been released in technical reports by the Flexible Plant Operations and Generation Pathway in the LWRS Program (Refs). Project deliverables should include detailed descriptions of the thermal and electric power simulator tools as well as recommended design requirements and potential improvements that are relevant to specific simulators/applications.

# LWRS – Physical Security

Strategic Goal - Create tools, technologies, and risk-inform physical security decisions and activities

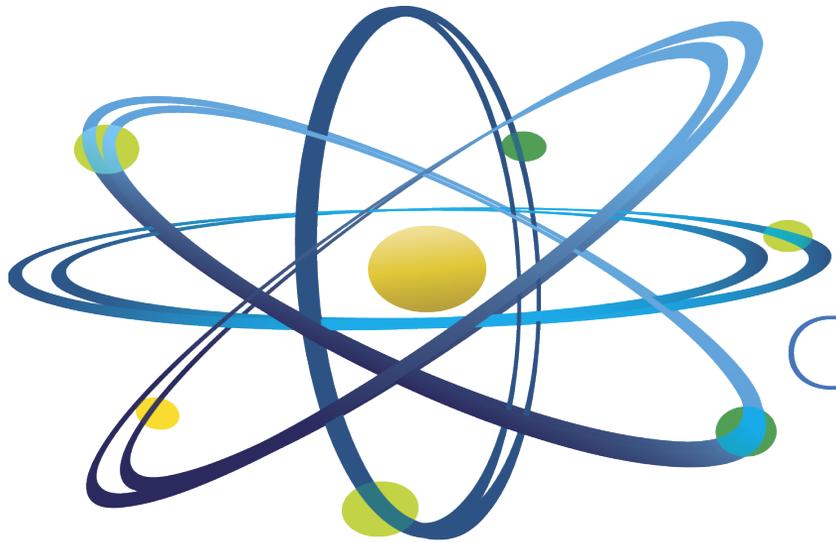
- Developing mitigation strategies and enhance the technical basis necessary for stakeholders to reevaluate physical security postures while meeting regulatory requirements.
- Create new technologies, methods, and tools to optimize physical security at U.S. nuclear power plants that address Design Basis and regulatory requirements.
- Near-term goal is to develop approaches to enable industry to operate nearer the staffing requirements of 10 CFR 73.55.



- **EVALUATION OF PHYSICAL PHENOMENA DATA IMPACT AND IMPROVEMENTS**

- The Light Water Reactor Sustainability Program Physical Security Pathway is soliciting research projects that will explore human reliability models that can be used in physical security modeling and simulation tools. During an adversary attack on facility, security and operations personnel are required to perform actions under significant stresses in order to prevent radiological sabotage. Potential models need to address the performance of operators and physical security personnel during the attack phase of a scenario and then human reliability of operators after a successful attack as they try to implement actions to prevent or mitigate a radiological release such as through the installation of FLEX equipment. Additionally, the models need to also include the human reliability of the adversary and response forces. This work should evaluate current human reliability models and explore/develop new methods for specific use in the above applications. The result of work needs to be a method that can be easily integrated into existing security modeling and simulation tools.

# Questions?



Clean. **Reliable. Nuclear.**