

Risk Metrics for Advanced Reactors EPRI Research Activities



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# **Advanced Reactor Roadmap**

A shared strategy to ensure success at scale



Serving government, academic, industrial, and public stakeholders



Almost 100 GWe of **new nuclear** will be needed by 2050. This means around **300 ARs** in the next **30 years** 



7 Enablers and 46 key actions chart our path towards a netzero future



Convening the industry for strategic action

## Industry's roadmap to the future fleet -



EPC



### **EPRI Research on Risk Analysis Methods & Tools for ARs**



- Determine the readiness of current risk methods and tools for use in Advanced Reactors
- Develop and execute a research roadmap to guide EPRI research to address new technology and new decisions
- Related ANT research:
  - Reliability & Integrity Management
  - Design support & safety analysis for a DOE-funded program
  - Method for separation of nuclear facilities from adjacent facilities



 Published EPRI report with identified gaps and a research roadmap (August 2023)



EPRI Report 3002026495 Evaluation of Risk Analysis Methods & Tools for Advanced Reactors

- Stakeholder collaboration group to share common challenges and approaches to solutions
- Upcoming wiki page to highlight and track research activities



- Continue monitoring & prioritizing the key challenges to assist the development and deployment of Advanced Reactors
- Expanding research in 2024+:
  - Risk Metrics for Advanced Reactors
  - Guidance for Passive System Reliability
  - Treatment of Very Low Frequency External Events

 Digital System Reliability Approaches

### **Risk Metrics for Advanced Reactors – Key Questions**

- While CDF and LERF/LRF work well for the current fleet of LWRs, what are their strengths and weaknesses for application to advanced reactors?
- What risk-informed decisions may be able to utilize the F-C curve developed in NEI 18-04? What types of applications may need a different or surrogate risk metric?
- What is the background for the NRC's Quantitative Health Objectives (QHOs), and what are its strengths and weaknesses for risk-informed decision making for advanced reactors?
- For advanced reactor designs that are not conducive to the use of CDF and LERF/LRF, what are the other options for risk metrics and how are they related to higher level objectives such as the QHOs?



### **Risk Metrics for Advanced Reactors - Background**

1E-4

1E-5

[\_\_\_\_\_] 1E-6

1E-7

- Background on CDF/LERF/LRF
  - How was development related to US Quantitative Health Objectives?
  - What are the underlying assumptions in current metrics?
  - What are global perspectives on metrics?
  - What are global thresholds for risk?
- Options for risk metrics
  - Analogies to CDF/LERF/LRF
  - New design-specific metrics
  - New technology-neutral metrics



### **Risk Metrics for Advanced Reactors - Current Assumptions**

#### Example: LERF as a Surrogate for the QHO

- Individual risk for prompt fatality in the US from all accidents: 5 x 10<sup>-4</sup> /year
- QHO criterion is 0.1% of all other risks, so QHO for an NPP: 5 x 10<sup>-7</sup> /year
- Individual early risk (IER):

$$IER = \sum_{1}^{N} CPEF_n * LERF_n$$

- CPEF<sub>n</sub>: conditional probability of early prompt fatality for accident sequence n
- LERF<sub>n</sub>: frequency of large early release for sequence n
- For a bounding calculation:
  - Worst case accident sequence with CPEF<sub>n</sub> = 3 x 10<sup>-2</sup>
  - LERF goal of 1 x 10<sup>-5</sup> / year
- IER =  $(3 \times 10^{-2}) \times (1 \times 10^{-5} / \text{year}) = 3 \times 10^{-7} / \text{year}$ 
  - Therefore, IER < QHO</p>

### Risk Metrics for Advanced Reactors – EPRI Research

- Key Characteristics for Risk Metrics
  - Focus on public safety
    - As codified in regulations
  - Technology-neutral
    - To apply to LWRs & NLWRs
  - International
    - To support global deployment



### Risk Metrics for Advanced Reactors – EPRI Research

- Primary Safety Metric(s)
  - Guidance for common metric selection
  - Focus on public safety
    - Considering a metric based on release and/or dose
- Preventive Safety Metric
  - Guidance for design-specific metrics
  - Loss of control of radioactive materials
    - Core Damage Frequency or similar
- High-Level Safety Objectives
  - Guidance to demonstrate that surrogate metrics are consistent with HLSOs
  - Underlying assumptions for Level 3 PRA



### Risk Metrics for Advanced Reactors – EPRI Research

#### Next Steps

- Interaction with regulators (this workshop!)
- EPRI Report under development
  - Background on risk metrics
  - Guidance for metric determination
  - Suggested Primary Safety Metric(s)
  - Targeted for release this fall



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