# EPRI Research on Risk Metrics for Advanced Reactors

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ANS RP3C Community of Practice
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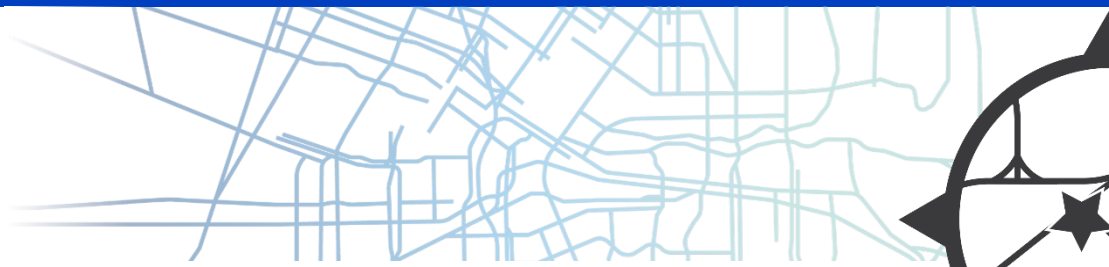
# AR Roadmap: Strategic Elements



## Regulatory Efficiency

- **Licensing** — 7 Actions
- **Environmental** — 7 Actions
- **Oversight** — 2 Actions

## Technology Readiness

- **Fuel Cycle** — 3 Actions
- **Plant/SSC Design** — 3 Actions
- **Supply Chain** — 7 Actions
- **Nuclear Beyond Electricity** — 3 Actions
- **Codes & Standards** — 2 Actions

## Project Execution

- **Project Management** — 4 Actions
- **Engineering & Procurement** — 2 Actions
- **Construction & Commissioning** — 3 Actions
- **Initial Operations & Maintenance** — 1 Actions
- **Workforce Development** — 4 Actions

Benefit from Risk Analysis Methods & Tools Research

# EPRI Research on Risk Analysis Methods & Tools for ARs

## OBJECTIVES

- Determine the readiness of current risk analysis methods and tools for use in Advanced Reactors
- Develop and execute EPRI research to address new technology and new decisions
- Support related ANT research
  - Reliability & Integrity Management
  - DOE sponsored work on advanced reactor design
  - Technical Methodology to Demonstrate the Separation of Nuclear Facilities

## PRODUCTS

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

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

## NEXT STEPS

- Continue monitoring & prioritizing the key challenges to assist the development and deployment of Advanced Reactors
- Tech transfer and collaboration to share common challenges and approaches to solutions

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# Risk Metrics for Advanced Reactors

## OBJECTIVES

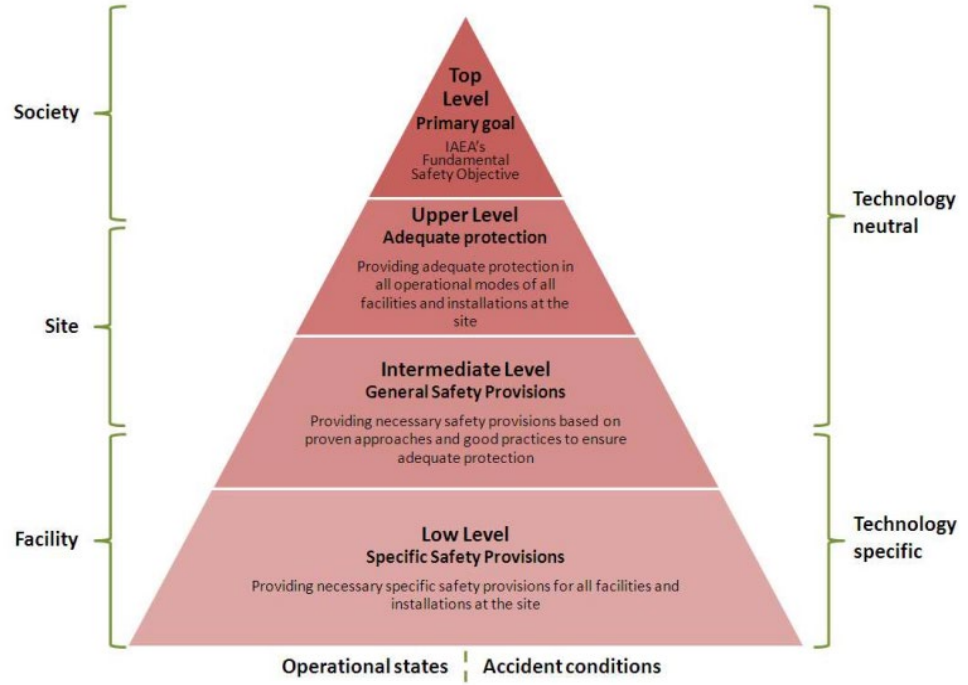
- Investigate the range of risk metric options available for use in advanced reactors
- Assess their strengths and weaknesses
- Recommend a common approach for advanced reactor risk calculations to support risk-informed decision making

## KEY QUESTIONS

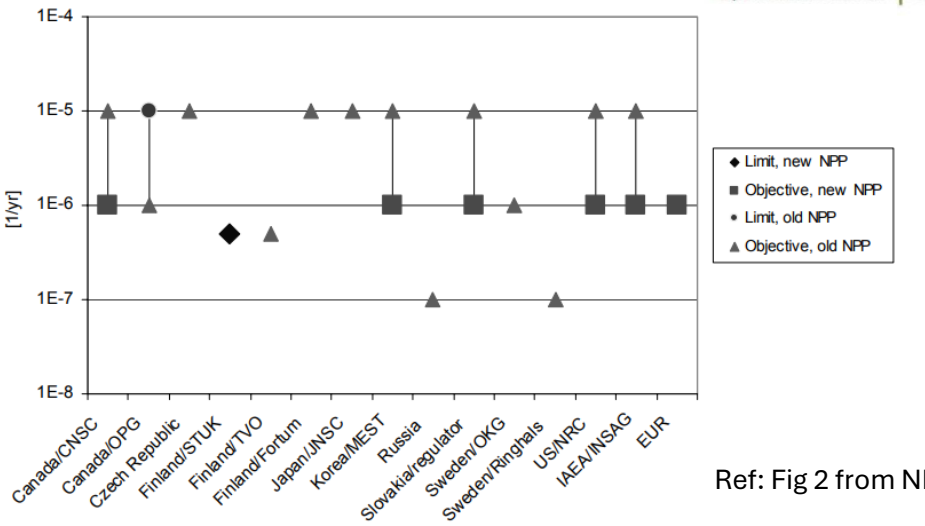
- While CDF and LERF/LRF work well for the current fleet of LWRs, what are their strengths and weaknesses for application to advanced reactors?
- What is the background for the NRC's Quantitative Health Objectives (QHOs), and what are its strengths and weaknesses for risk-informed decision making for 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

- 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
  - Existing options (e.g., NEI 18-04)



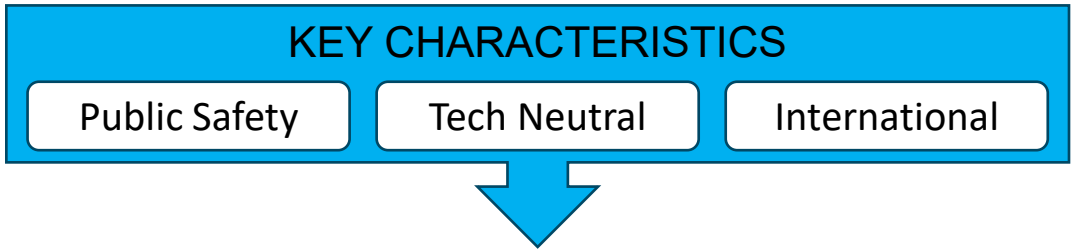

Ref: Fig 2 from IAEA TECDOC-1874




Ref: Fig 2 from NEA/CSNI/R(2009)16

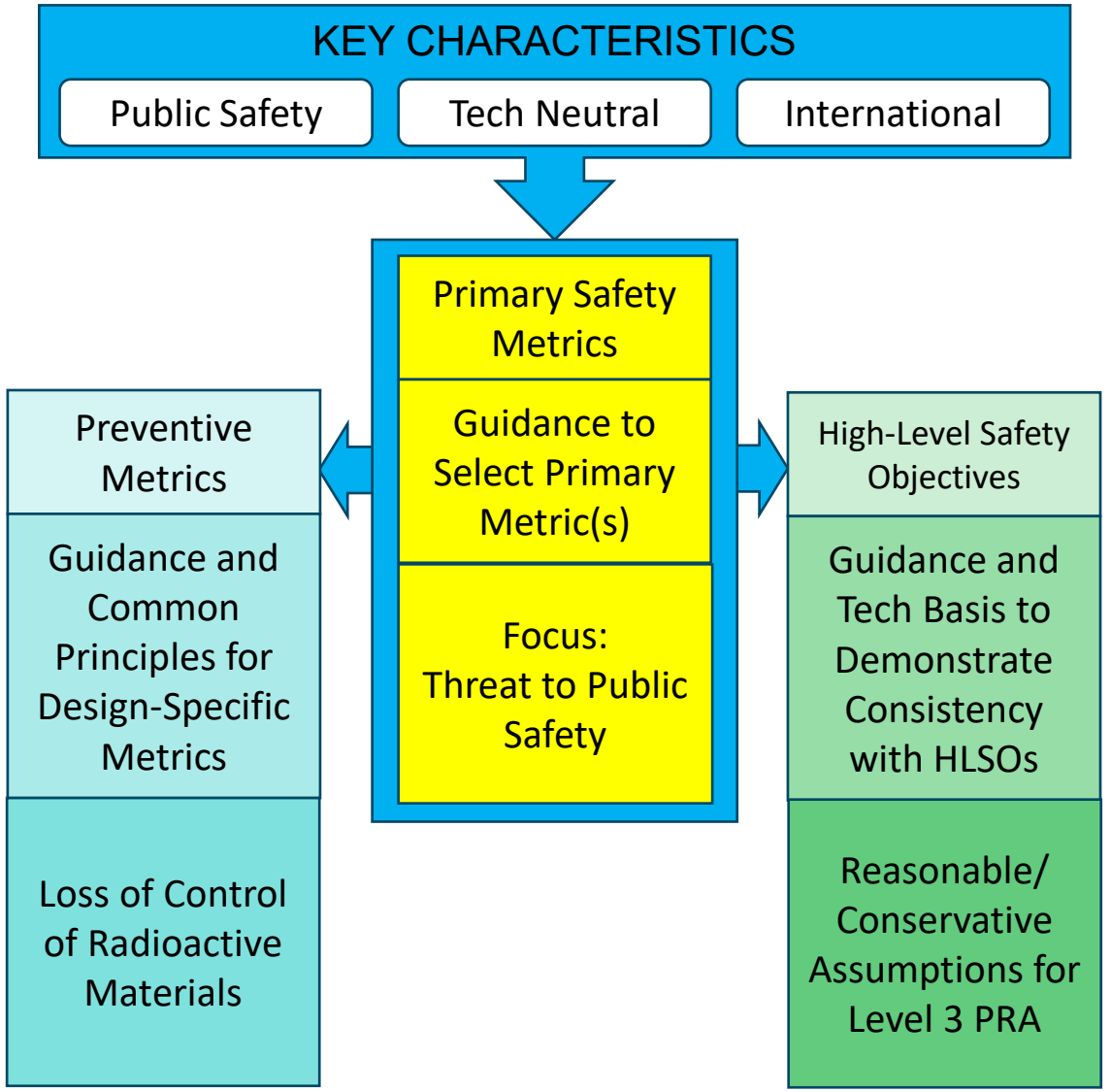
# Risk Metrics for Advanced Reactors – EPRI Approach

- 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 Approach

- Primary Safety Metric(s)
  - Guidance for common metric selection
  - Focus on public safety
    - Potential metrics 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

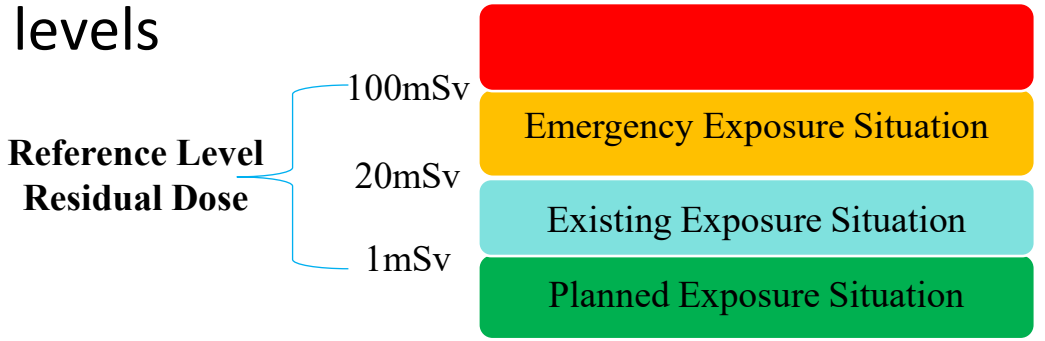


# Component 1: The Consequence

- Recommended consequence: Dose
  - Non-selected options
    - Large/Early Release – difficulty in variable definitions, dependencies on offsite actions, questionable applicability to some designs
    - Activity of Release – difficulty in selection of specific radionuclides due to variation among different reactor fuel types, assumptions related to offsite impacts
      - May be useful for land contamination or other impacts
  - Why dose?
    - Independent from reactor design
    - Direct measure of potential offsite impacts
    - Existing regulatory requirements and other documents

# Component 2: The Consequence Metric

- Primary goal: Focus on public safety
  - Limit the need for offsite response to protect the public
- Emergency action levels vary by regulatory authority
  - IAEA GSR Part 7 provides reference dose levels
    - 50mSv for evacuation
  - US Protective Action Guides
    - 10-50mSv (1-5 rem) over 4 days
      - Shelter-in-place / evacuation



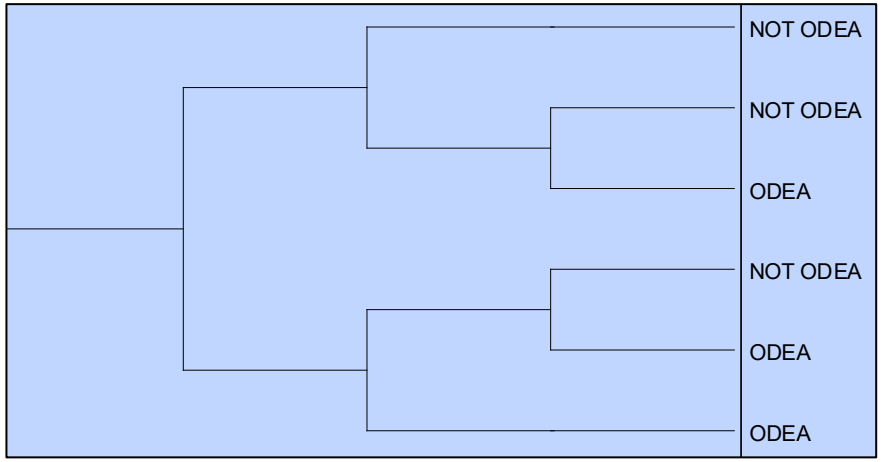

- Distance for the dose can be set at the boundary to align with goal to limit the need for offsite response
- Recommendation: specified dose at the boundary for a set time
  - Dose of 50mSv (5 rem) encompasses most definitions for necessary offsite action
  - Recognize that different regulatory environments may require different definitions

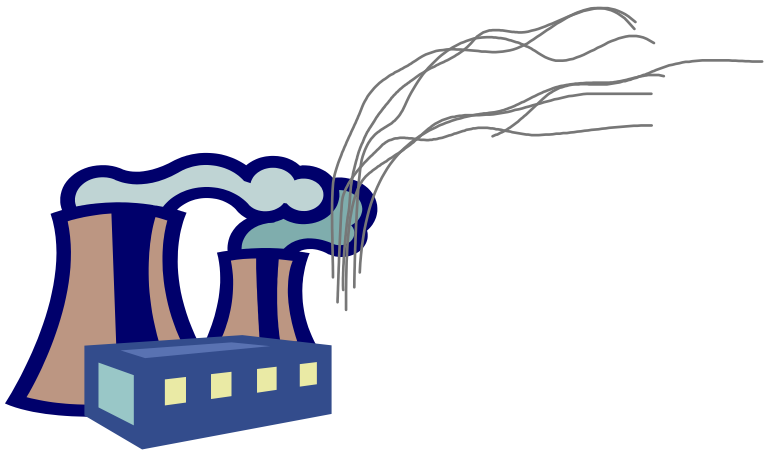
# Component 3: Frequency & Acceptance

- Components 1&2 indicate a risk metric for exceeding a defined level of offsite dose (e.g., 50mSv)
  - Doses below the selected limit would have insignificant offsite impacts
  - Metric can be calculated as end-state of Level 2 / early Level 3 PRA model
    - Sum of sequences exceeding the defined dose limit
    - Fractional contributions from sequences may also be considered
- Considerations for a target value
  - A range of risk targets exist, but none match this metric yet
  - Different plant designs may require a different target value based on different maximum potential release
  - If a facility is below the to-be-identified target, then the QHOs or other high-level safety objectives can be assumed to be met

# Suggested Primary Technology Neutral Risk Metric

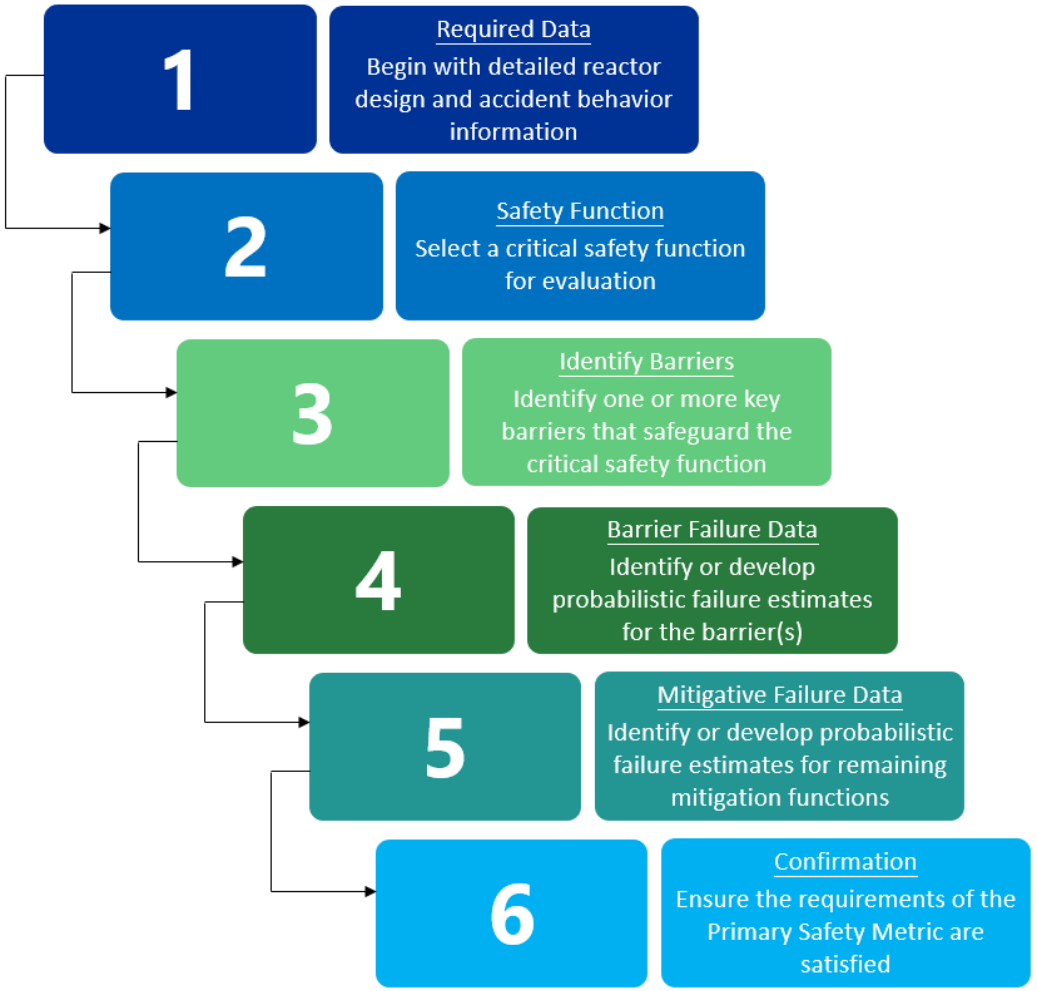
- Offsite Dose Emergency Action Frequency (ODEAF)
  - Use best-estimate consequence estimates based on current PRA expectations
    - Subject to regulatory requirements for dose calculations
    - Simplified/conservative approaches may be acceptable in some cases
  - Geographic boundary to be defined by licensee (e.g., site or EAB)
  - Include consideration of all hazards and all sources
  - Meets the PRA purpose to address the low-frequency/high-consequence realm
  - Differentiates between licensee vs regulatory authority



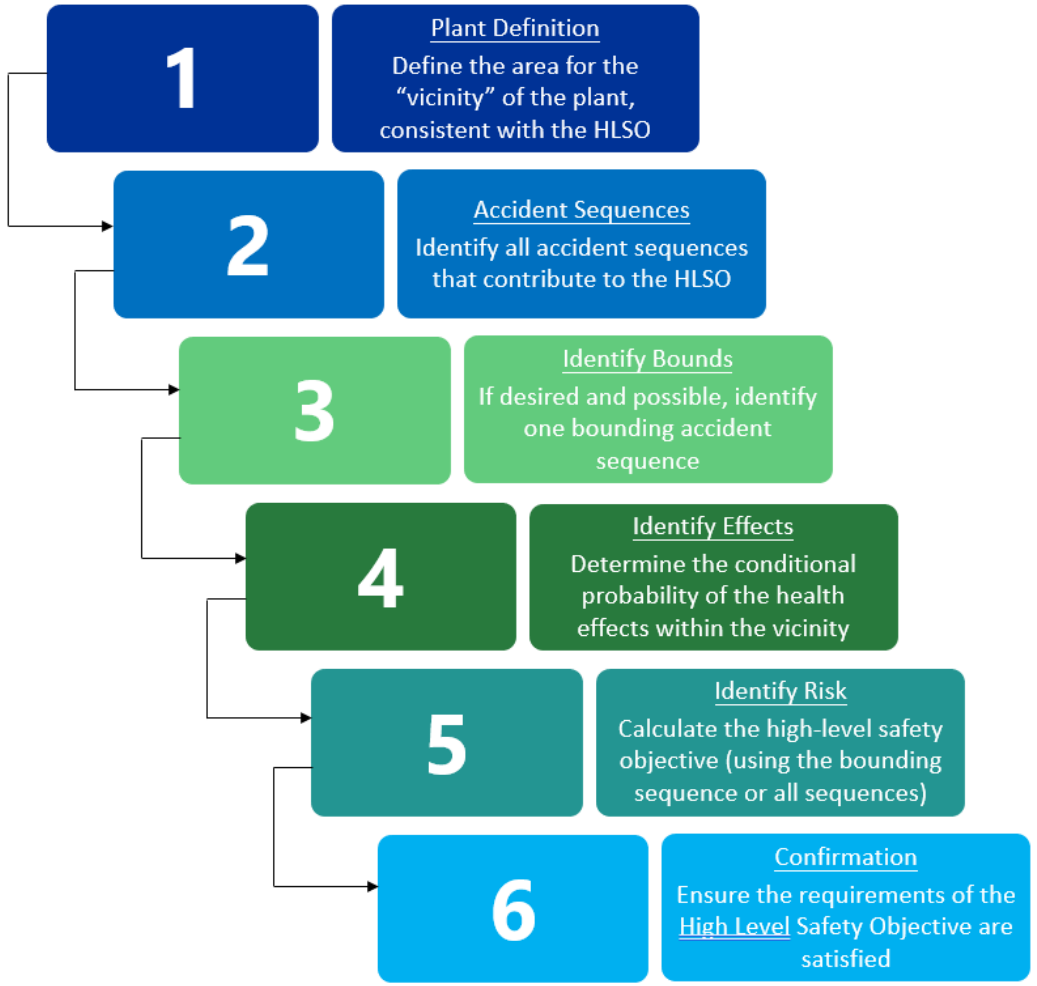
# Guidance for Preventive Metrics

- Purpose: Indicate accident scenarios prior to offsite release to support defense in depth
  - Allows for actions to be taken to remedy the undesirable plant safety performance
  - Indicates a change in the reactor's state of operation that defeats a layer of defense-in-depth
  - Available supporting methods such as Objective Provision Trees from IAEA TECDOC-1570
  - EPRI report includes a technology-neutral approach to identify and select appropriate preventive metrics



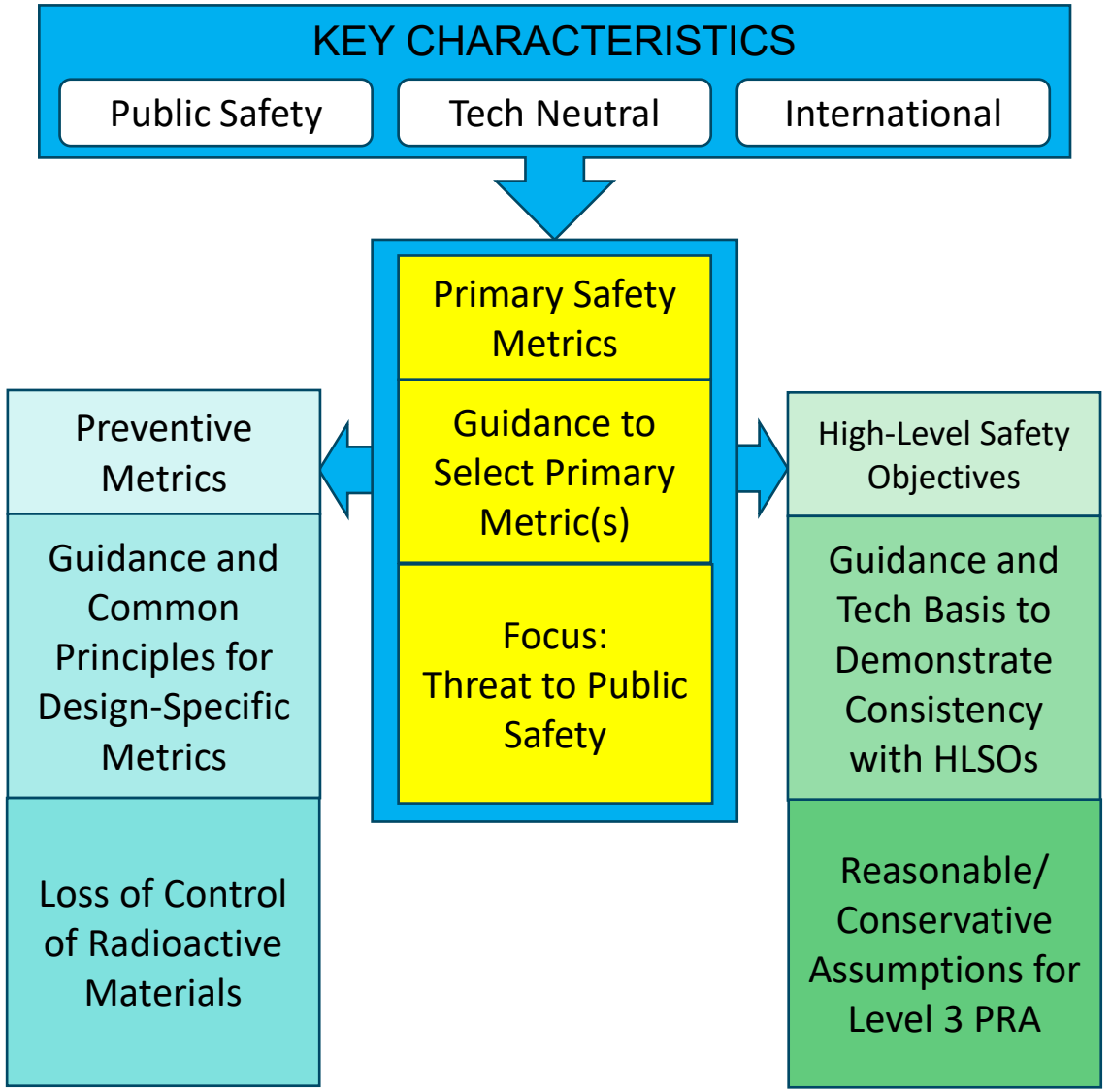
# Guidance for High Level Safety Objectives

- Purpose: Justify the use of the surrogate metric
  - Linkage of the primary risk metric to national and/or international high-level safety objectives
  - Identify and re-evaluate assumptions related to existing surrogate metrics
  - Identify plant-specific information needs (related to Level 3 PRA)
  - EPRI report includes a technology-neutral approach to demonstrate consistency between surrogate metrics and high-level safety objectives



# Risk Metrics for Advanced Reactors – EPRI Research

- Next Steps
  - EPRI Report 3002029252, Guidance for Selection of Risk Metrics for Advanced Reactors
    - published November 2024
  - Interaction with regulators and other stakeholders



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