Small Modular Reactors
Emergency Planning Zone

Nuclear Energy Institute White Paper

October 28, 2014

Presentation Objectives

- Ensure planned responses fully answer NRC questions
  - Within the scope of the NEI White Paper on EPZ
  - Calculation methodology
  - Identify when and how additional information may be provided
  - NRC will be able to reach a conclusion on the White Paper
- Discuss proposed path forward on SMR emergency planning

Subject Areas of NRC Questions

Subject Area	Associated Questions
SMR design features	1
Application of White Paper in context of broad SMR EP effort	2a, 2b, 2c
Accident scenario identification and use of probability	4, 9, 10, 11, 14
Uncertainties and enhanced plant capabilities	5, 18, 19, 20, 24, 25, 26
Application of risk-informed judgment	5, 23, 27
Probability of dose exceedance	15, 16, 17
Incorporating lessons learned	3a, 3b
Multi-module effects	3b, 6, 12, 13
Operationally-focused mitigation strategy	21, 22
Tools and models	4, 7a, 7b, 7c, 8

SMR Design Features (Enhanced Safety Inherent in the Design of SMRs)

- Smaller core fission product inventories
- Improved design features
  - Eliminate large-break loss of coolant accident
  - Location below ground level
  - Large primary coolant volume relative to thermal power
  - Fission product release path through containment water pools (some cases)
  - Greater number of reactor coolant pumps (some cases)
  - Natural circulation during normal and post-accident (some cases)
  - Internally mounted control rod drive mechanisms (some cases)
- Slower accident progression
- The specifics and the effects of these features to be addressed as part of design certification submittals

Application of White Paper in Context of Broader EP Effort

- Combined license applicants will use the methodology supplemented by design-specific information
  - This would include design specific source term calculations to provide a technical basis for an appropriately sized EPZ for the given design and site
- EPZ size basis will inform planning standards implementation
  - Planning standards won't inform EPZ size
- Industry plans to develop an SMR generic EP framework
  - Evaluate planning standards to determine how they should be adapted for SMRs
  - Applicants will also evaluate planning standards and their design-specific implementation since the technical basis for EPZ size* is expected to inform the planning standards

**Including fission product release magnitude and the "time between the onset of accident conditions and the start of a major release" (NUREG-0654, page 13)*

Accident Scenario Identification and Use of Probability

- Scenario selection process
  - 1E-8 per plant year is an initial step but not a cut-off frequency. The process does the following:
    1. Accident sequences with mean core damage frequency (CDF) greater than 1E-8 per plant year are selected and grouped into accident scenarios
    2. For Criterion b,* recognizing that SMR CDFs are typically quite low and that some SMR designs may not have any accident sequences greater than 1E-8 per plant year, there is an additional step to address even lower frequency intact containment sequences.
    3. For Criterion c,* the 1E-8 per plant year accident sequence frequency is to be extended to lower frequencies to assess potential cliff-edge effects.

* Criterion b and c from NEI white paper

Accident Scenario Identification and Use of Probability

- Intact containment severe accident scenarios
  - Those with core damage where containment functions as designed (i.e., isolates and remains intact)
    - Tend to be the more probable, less severe accidents to be addressed in Criterion b
    - Contribute to dose due to design basis (tech spec) leakage, and are to be compared to the EPA 1 rem and 5 rem TEDE PAGs
- Use of frequency to inform accident sequence selection
  - Apply concept in the five NRC documents to SMRs:
    - The five documents were cited in the White Paper for information to note where use of frequency (1E-7 per year in these five cases) was considered a reasonable concept for informing a risk application or regulatory decision
    - Incorporate this concept but with lower frequencies plus multiple, additional layers of defense-in-depth

Uncertainties and Enhanced Plant Capabilities

- Initiating events, operating modes, Level 2 PRA
  - Expected that applicants will
    - Apply guidance in ISG-28
    - Develop design-specific methods
    - Refer to trial-use guidance on Level 2 PRA pending completion of pilot applications and NRC endorsement
  - Applicants may also choose to address risks for areas which do not yet have endorsed standards by margins type approach or other systematic evaluation technique

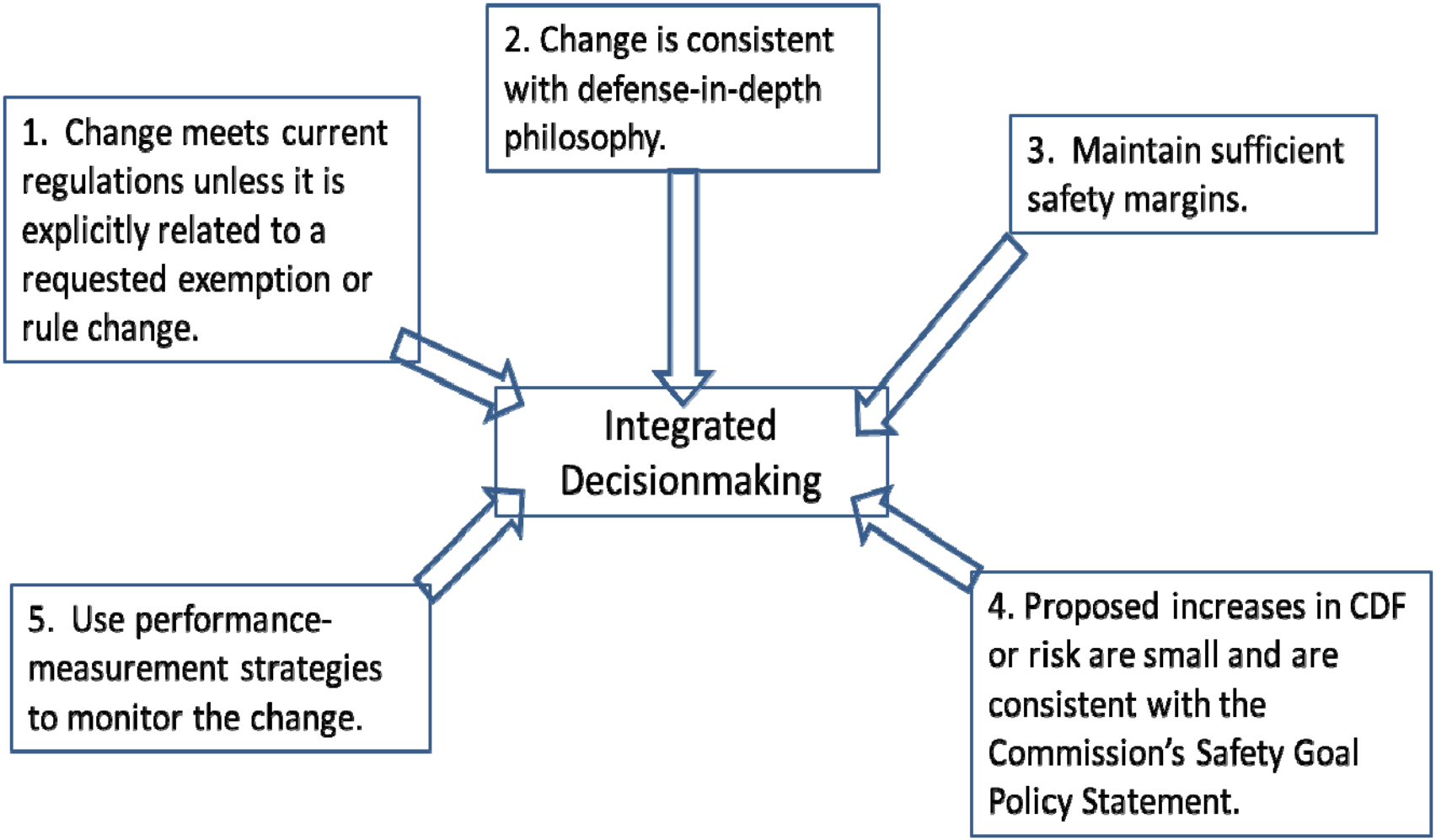
Uncertainties and Enhanced Plant Capabilities

- Enhanced plant capabilities
  - These are features not required to address design basis events, but rather provide additional layers of defense-in-depth
  - Complement to the PRA-based evaluation
    - It is more qualitative and deterministic
    - It is intended to address and compensate for uncertainties in PRA results and matters which cannot be treated in the PRA
  - There are four areas where enhanced plant capabilities are applied
    - Address completeness uncertainty including a diverse and flexible operationally-focused mitigation strategy
    - Address potential risks not fully addressed in the PRA
    - Assess potential impact on risk of lower frequency accidents (cliff edge effects)
    - Provide a capability for expansion of response

Application of Risk-Informed Judgment

- Risk-informed judgment and use of insights
  - Information and insights from PRA are considered together with deterministic, engineering evaluations and additional defense-in-depth capabilities as inputs to a deliberative decision-making process
  - Details to be developed as part of design-specific applications
  - Used to inform an appropriately sized EPZ
  - Figure 2 in NRC Regulatory Guide (RG) 1.174 (next slide) is an example

Principles of R-I Decision-Making (RG 1.174)



Probability of Dose Exceedance

- Use of absolute probability
  - Provide better representation of risk
    - For accident frequencies that are significantly lower than in large plants
  - Does not contradict the concept of layers of defense-in-depth being independent
    - Prevention based on features which are diverse and substantially independent from mitigation features
- Both absolute and conditional probability approaches should be available
- Applicants would justify the approach selected

Incorporating Lessons Learned

- The following lessons learned from the Fukushima Dai-ichi accident are reflected in the white paper methodology:
  - The need to consider risk from less probable external events and co-incident beyond design basis events is addressed
  - Provision of an operationally-focused mitigation capability is specified to address PRA completeness uncertainty and the need to maintain basic safety functions in the face of extreme events
  - Consideration of multi-module effects
  - Spent fuel pool accident risk is to be addressed
  - As part of development of EP planning standards, it is to be confirmed that a capability for expansion of response exists if necessary

Multi-Module Effects

- Meeting the NRC June 2014 proposed criteria would ensure:
  - Prevention of multiple core damage events
  - Multi-module sequences are not significant contributors to risk and large release
  - Operational strategies provide ability to mitigate impact of multi-module accidents on public health and safety
- Expected that applicants will meet the NRC criteria
- Multi-module effects are not expected in dose comparison against PAGs due to the very low frequency for such effects
- Even if a multi-module accident occurred
  - Accident progression not expected to be identical from one module to another (source terms staggered in time) and doses would not be additive
  - Thus “coincident core damage events” are not considered realistic
- Multi-module effects on EPZ to be addressed in design-specific submittals

Questions Not Fully Resolved Through the NEI White Paper

- Topics outside the intended scope of white paper
  - Broader EP framework
- Topics requiring design specific information
  - SMR design features (enhanced safety)
  - Multi-module effects
  - Acceptance values of risk metrics
  - Examples of merging risk insights and defense-in-depth considerations
  - Operationally-focused mitigation strategy
  - Inputs and validation of analytical tools, models and inputs
  - Development of Level 2 PRA methods

Desired Outcomes

- NEI submits responses to NRC - November, 2014
- NRC concludes that industry approach (White Paper and responses) provides a reasonable basis for developing specific applications
- Individual applicants will provide design-specific information to NRC
- Industry and NRC will have discussions on broader emergency planning SMR framework