GAIN-EPRI-NEI Advanced Reactor
Safeguards & Security Virtual Workshop
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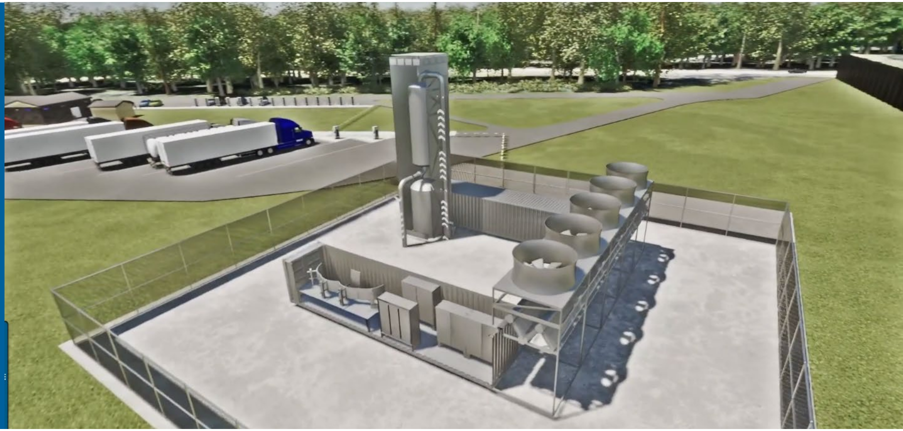
FRAMEWORK FOR MICROREACTOR SAFEGUARDS AND SECURITY



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U.S. DEPARTMENT OF ENERGY

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PROJECT OVERVIEW

- The goal of this project is to develop a guide/rubric for domestic safeguards.
- The guide will take the form of a two-step procedural framework, based on analytical assessments, as well as modeling and simulation (M&S).
- Products will assist in producing evidence for the NRC of safeguards advantages and/or challenges and how they are utilized or effectively negated.
- Step 1 of this framework involves identifying the safeguards and security considerations and potential gaps.
- Step 2 of the framework is the procedure to address each of these identified considerations.

GOALS AND OBJECTIVES

- Goals
  - Produce products that will be impactful, easy to understand and easy to use
  - Assist in bridging the gap between the NRC and vendors on domestic safeguards
  - Utilize expertise in nuclear fuel cycle and advanced reactor safeguards, microreactor design, analysis, and modeling and simulations

- Objectives
  - Evaluate a comprehensive set of microreactor features
  - Apply modeling and simulations, and analytical assessments
  - Include a decision-tree or similar that will allow for road mapping
  - Apply our matrix to a microreactor concept

SCOPE AND METHODOLOGY

- Scope
  - Any new non-light water reactor concept, less than 30 MWe
  - Focused only on the reactor facility and surroundings for domestic safeguards
  - All design features that would influence safeguards (safety-crosswalk)
- Methodology
  - Examine current MC&A and PSPP practices
  - Assess assumptions
  - Map practices to microreactors
  - Use “Outside-In” approach to MC&A and PSPP analysis
  - Document found gaps and strengths as a generic decision matrix
  - Perform Analytical Assessments and Mod/Sim specific to the matrix

Reactor concept	Residence	Core Features	Safety Features
Metallic-fueled, heat-pipe cooled, stationary reactor	• One location for its entire life cycle	• May or may not be sealed core • Possible need to rearrange fuel	• Secondary structures expected • Below-grade siting
TRISO-fueled, heat-pipe cooled, mobile reactor	• Multiple locations for an unspecified amount of time at each location	• May be sealed core • Onsite refueling will not be pursued	• Reactor in a mobile-at-will or mobile-at-ready operational mode. • No additional, onsite infrastructure
TRISO-fueled, gas-cooled, mobile reactor	• Multiple locations for an unspecified amount of time at each location	• May be sealed core • Onsite refueling will not be pursued	• Reactor in a mobile-at-will or mobile-at-ready operational mode. • No additional, onsite infrastructure
TRISO-fueled, gas-cooled, stationary reactor	• One location for its entire life cycle	• Most likely a sealed core • Cartridge refueling swap	• Secondary structures expected • Below-grade siting

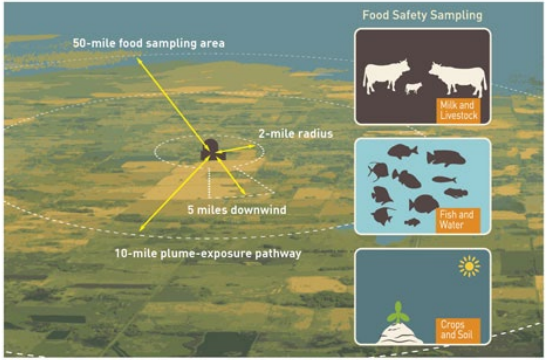
RECENT RESULTS

- Our recent results have been focused on Step-1 of our framework. They include:
  – Advanced safety features and their implications to Domestic Safeguards.
  – Analysis of MC&A scenarios involving microreactors.
  – Analysis of PSPP scenarios involving microreactors.

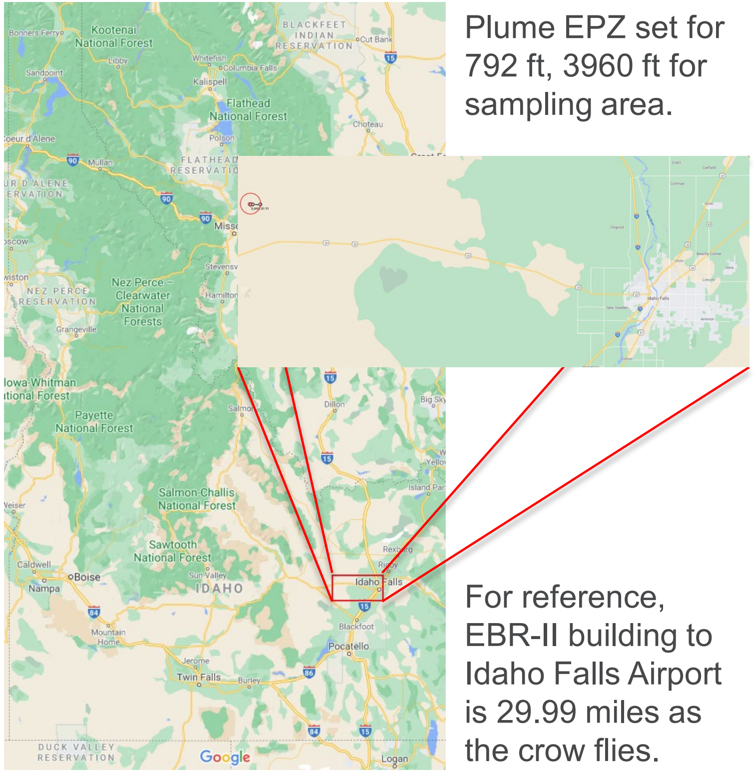
ADVANCED SAFETY FEATURES IMPLICATIONS TO DOMESTIC SAFEGUARDS – EPZ

- Microreactors are "less than 250 MW thermal” and won’t be held to fixed EPZs set for large LWRs.
- Key considerations for a reduced microreactor EPZ
  – lower source term inventory,
  – lower fission product release potential,
  – longer time to release an amount of radiation of significance,
  – any unique concept characteristics that further impact these or other accident properties.

Emergency Planning Zones



Note: A 2-mile ring around the plant is identified for evacuation, along with a 5-mile zone downwind of the projected release path.



Plume EPZ set for 792 ft, 3960 ft for sampling area.

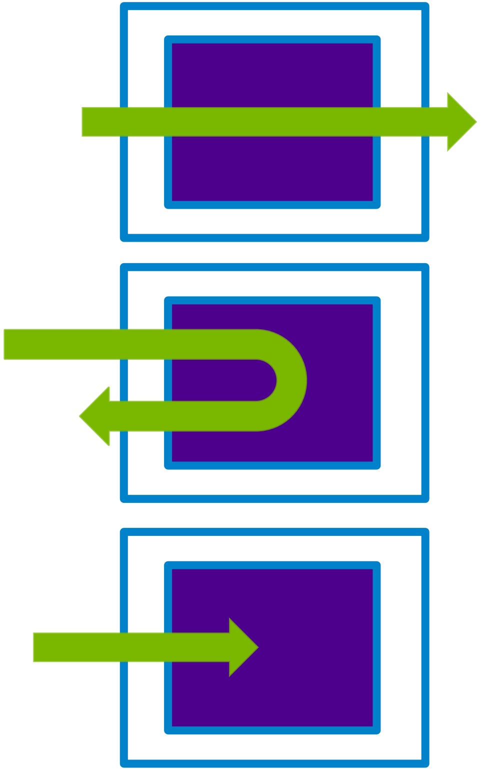
For reference, EBR-II building to Idaho Falls Airport is 29.99 miles as the crow flies.

ADVANCED SAFETY FEATURES IMPLICATIONS TO DOMESTIC SAFEGUARDS – PASSIVE SAFETY

- The specific scenario with the greatest or most severe consequence is largely dependent on the specific reactor concept and its coolant, safety features, and other parameters.
- For evaluation of maximum credible accidents for microreactors, NUREG-0800 outlines what should be considered. Loss of heat sink for non-water-cooled concepts tends to be the scenario with the greatest or most severe consequences.

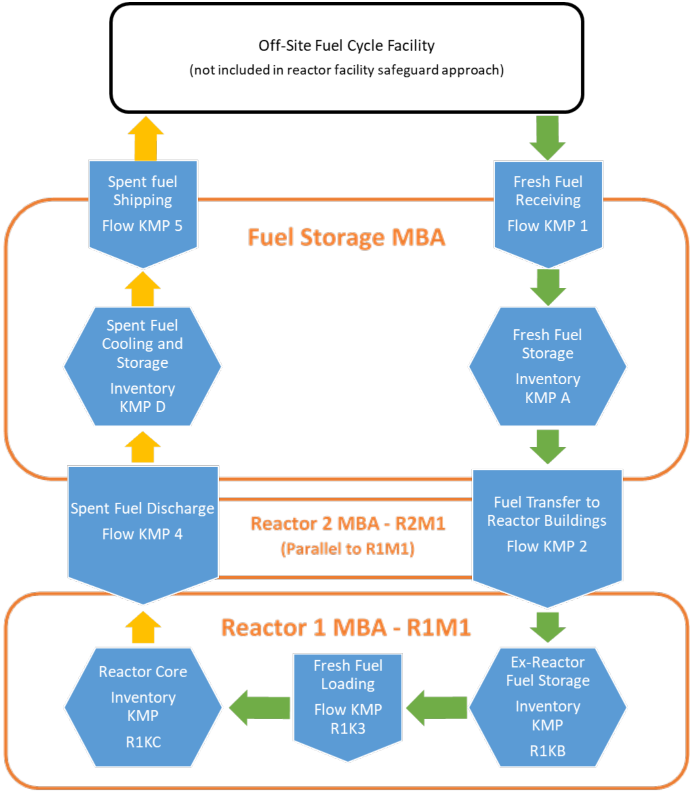
“OUTSIDE-IN” APPROACH TO MC&A AND PSPP ANALYSIS

- “Outside-In” is a methodology to look at how threats would be applied against assets.
- Essentially, a threat must by-pass protections (barriers, security, etc.) to get to their objective. Then either leave by a new path, via the path of entry, or the scenario might not require exit at all.
- In this case, each blue box represents a layer of “protection” where the purple is the target area or objective.



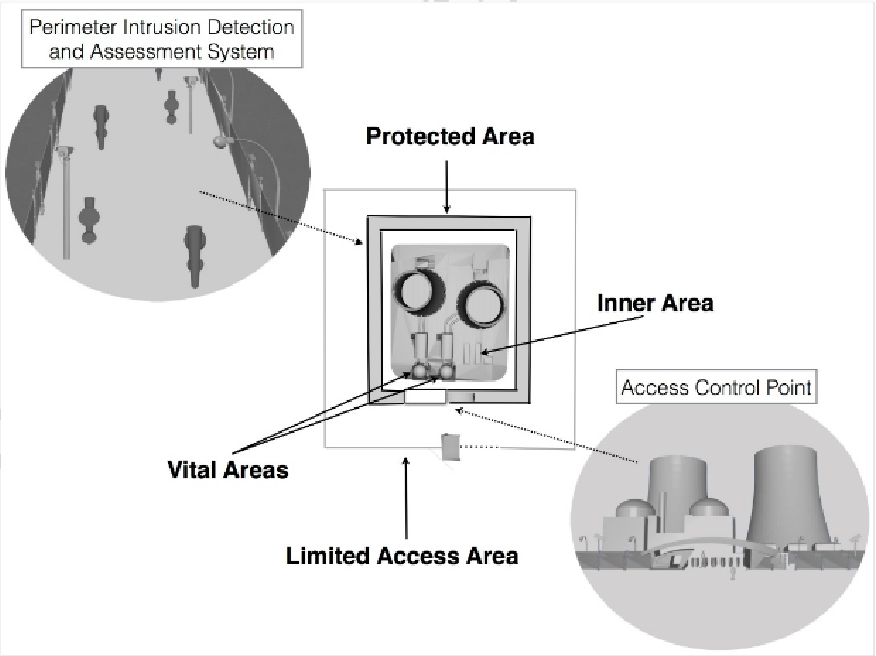
MC&A

- The material control and accountancy (MC&A) for microreactors will depend very much on how the reactor will receive, transfer, arrange, eject, and cool fuel.
- The 4 generic concepts all rely on reducing the number of fuel "items"
- If it can be demonstrated that reliable accounting, recordkeeping, identification, and continuity of knowledge can be kept on each item, at the same level of confidence or greater than the current domestic reactor fleet, then the reduced number of fuel items will make MC&A less burdensome at the reactor site.
- This last point is very much dependent on the MC&A plan that will be employed.



PSPP

- The physical security and physical protection (PSPP) scenarios for microreactors did not seem to have a common set of attributes. This is due to the wide variety of features for each reactor.
- However, vendors may already consider these scenarios and factors related to the PSPP. We believe that further work with the vendors concerning each physical protection scenario may be warranted to demonstrate an adequate plan to the NRC, dependent on performance.



FUTURE WORK: NEAR-TERM

- Developing the Step-2 of the framework
  - Focus on requirements to reactor characteristics
  - Creation of the decision matrix based on the “outside-in” methodology
  - Properly cite the MC&A and PSPP strengths of those reactor characteristics within the matrix
  - Identify the disadvantages or gaps that must be addressed by the matrix
  - Reach back to NRC on analytical assessments on strengths and gaps as captured by the matrix
  - Identify Mod/Sim path for application to the matrix and bring up to full speed
  - Report Matrix and final products to DOE-NE, with DOE-NE distributing to interested vendors and developers

LONGER-TERM ACTION PLAN

- Apply the decision matrix to a microreactor concept, look at how the framework fits the concept and vice versa.
  - Potential to apply the decision matrix to a concept from Industry
    - Please contact DOE-NE, NE-5 ARS Program if interested
  - Options from the National Laboratories
    - Megapower: Los Alamos National Laboratory
    - MiFi-DC : Argonne National Laboratory
- Document the outcome and report it to the ARS Program and Concept Designers

CONCLUSION

- Project is focused on microreactors and helping vendors to identify MC&A and PSPP approaches for their concepts, both strengths and gaps.
- The team identified that a part of the project will be to open communication and understanding between regulators and vendors.
- Team has identified multiple concepts that are close to market. We will also need to keep peripheral concepts in mind and not silo MC&A and PSPP considerations.
- The team has begun discussing with NRC and has already identified some useful information which will be relevant to our own and other projects.
- Applicability of safety to security-related outcomes have been identified.
- Application of MC&A and PSPP via the “outside-in” methodology to concepts have been documented.