ADVANCED REACTOR SAFEGUARDS

Framework for Microreactor Safeguards and Security

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Project overview

- The goal of this project is to develop a guide/rubric for domestic safeguards.
- Products will assist advanced reactor designers/vendors in producing evidence for the NRC of safeguards advantages and/or challenges and how either is being addressed.
- 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.

Overview of Accomplishments in FY22

- Finished Step-1 report and submitted for group feedback. The report focused on:
  - Advanced safety features and their implications to Domestic Safeguards.
  - Analysis of MC&A scenarios involving microreactors.
  - Analysis of PSPP scenarios involving microreactors.
- Began work on Step-2 of our framework. This includes:
  - Laying out pathways to safeguards resolutions as a user-driven choice. (Decision-tree graphics)
  - Explaining the graphics in short, concise and impactful dialogs
  - Expanding these graphics to other non-microreactor concepts

Findings in Step-1 Report

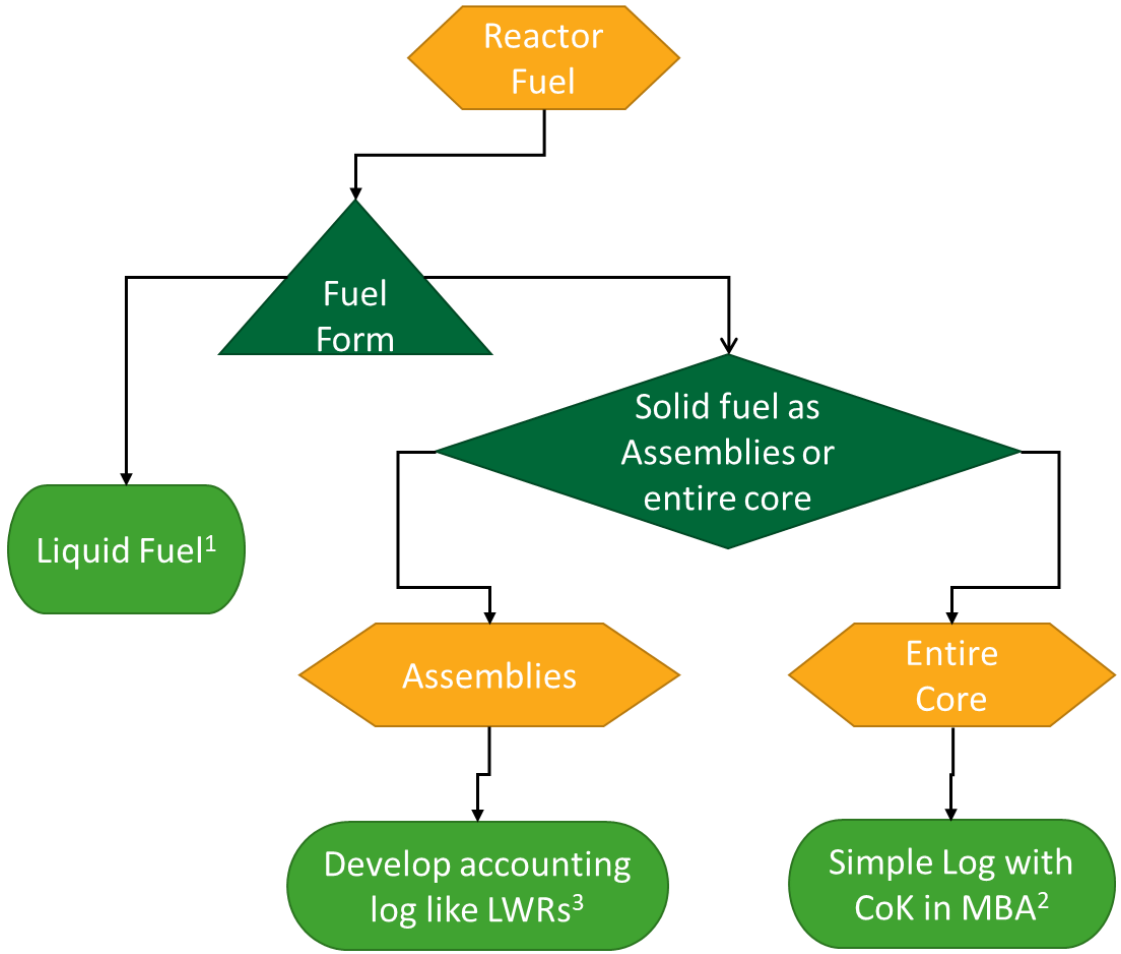
- Within the field of MC&A:
  - 1) use of calculations, and simulation and modeling for spent fuel;
  - 2) inventory tracking of the site and its detail for continuity of knowledge;
  - 3) protocol for NRC safeguards inspections;
  - 4) MC&A practices appropriate for fueling concept (i.e., pre-loaded lifetime core or on-site fueling and refueling); and
  - 5) anomaly detection and resolution in a remote environment or a restricted access or inaccessible location.

Findings in Step-1 Report

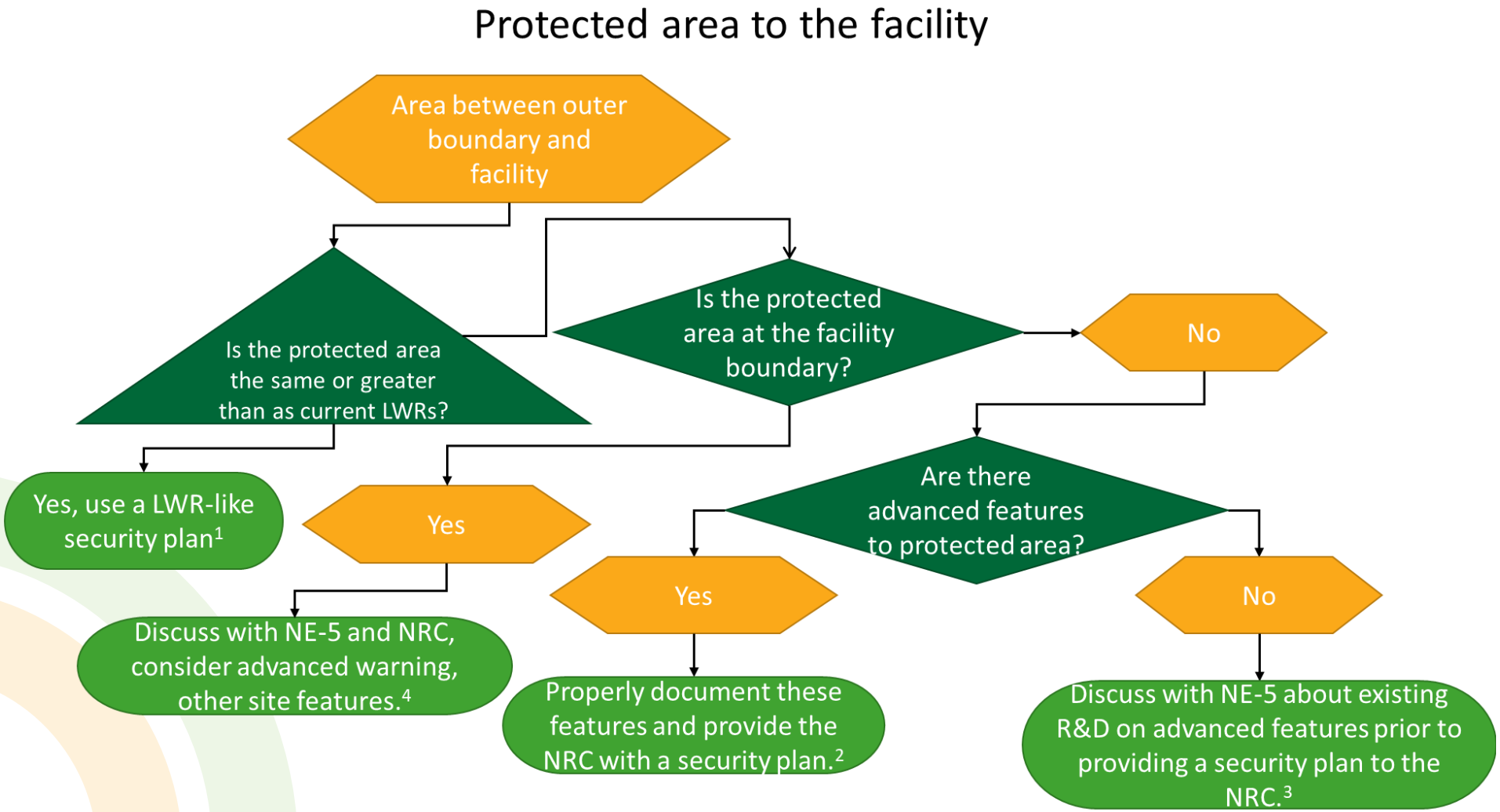
- Within the field of Security:
  - Formal documentation of how reactor features affect physical security
  - “Reinforcing” the stand-off area, if smaller than conventional reactors
  - Possible improvement in quicker and higher confidence site intrusion detection and assessments
  - Reducing access points to primary structures (i.e., the reactor building)
  - Localize and minimize the areas that are of paramount security interest (decreasing the security cross-section)
  - Specialize the approval and authority to access areas of paramount security interest
  - On-site and off-site force augmentation for meeting threats
  - Advanced force multiplier deployment for countering an intrusive force

Work on Step-2 Report: MC&A example

Fuel tracking in the facility



Work on Step-2 Report: Security example



Work planned for Fiscal Year 2022:

- Microreactor Domestic Safeguards Framework:
  - Work on completing Step-2 of the framework (addressing Gaps and Strengths)
  - Provide initial product to DOE-NE by mid-summer for initial feedback
  - Report Matrix and final products to DOE-NE by year end
- Outreach With Industry:
  - One industry partner already, we are looking for two more partners.
  - Begin applying Framework to a microreactor concept.
  - Update the sponsor based on these interactions
- Update Framework to address concepts other than microreactors.

Conclusion

- Report 1 has been finished; Report 2 is underway.
- Report 1 findings emphasized previous findings in the project:
  - MC&A will be straight forward and will look identical or only slightly modified from current practices. The exception is liquid/bulk fuel not itemized.
  - Security will require a considerable amount of work by the vendors to present a plausible and actionable security plan. However, there are many opportunities in this space for R&D that will help to alleviate this burden and meet NRC requirements.
- Two flowsheets from Report 2 have been presented and we welcome any feedback.
- Finishing Report 2 is our highest priority with expansion of the report past microreactors and inclusion of industry in our process being highly desired.

Back-Up Slides

Goals and Objectives

- Objectives:

This study has the overall objective of informing, working with, and assisting industry with NRC Domestic Safeguards requirements that are part of the final licensing steps for reactor concepts.

  - Evaluate a comprehensive set of microreactor features, expanding to features of other select concepts.
  - Include a decision-tree or similar that will allow for road mapping (as requested by industry feedback).
  - Apply our matrix to a microreactor concept, expanding to other concepts.

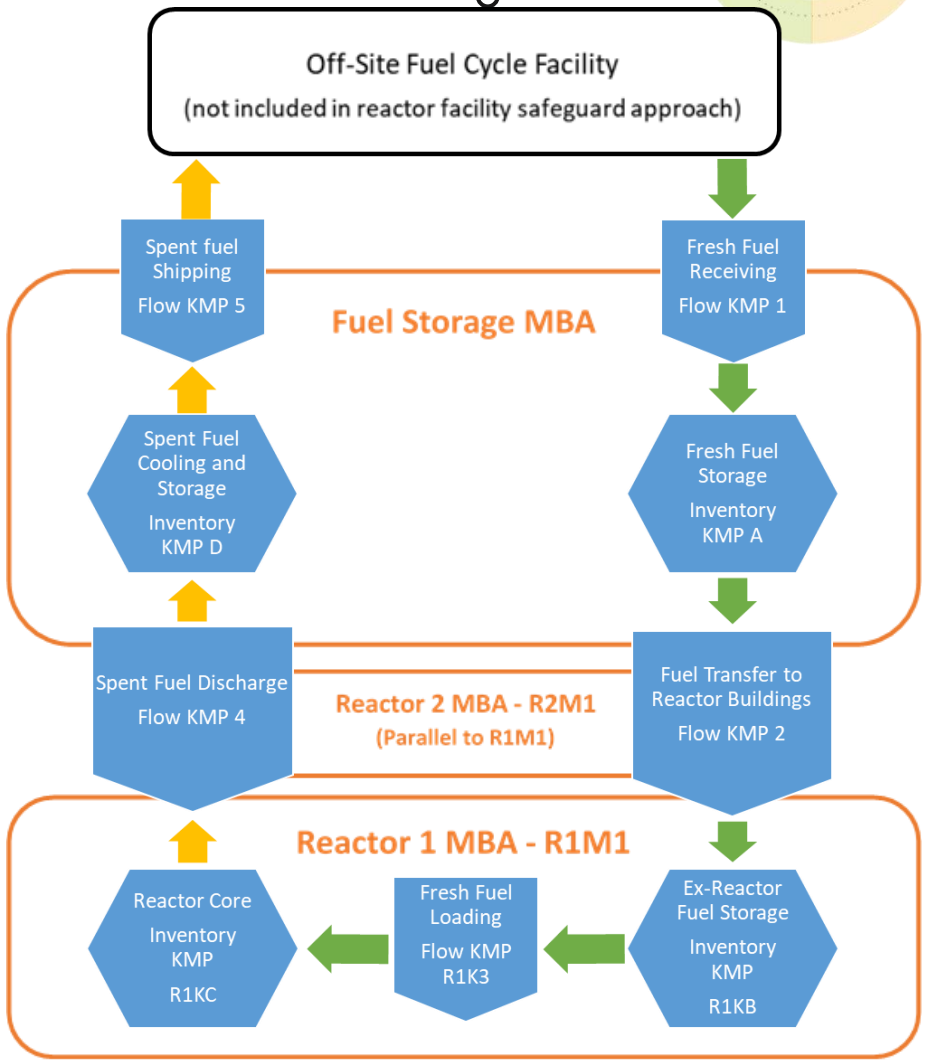
- Goals
  - Produce products that will be impactful, easy to understand and easy to use, reduce time and increase effectiveness to safeguard and security readiness for industry.
  - Assist in bridging the gap between the NRC and vendors on domestic safeguards.
  - Utilize expertise in nuclear fuel cycle and advanced reactor safeguards, reactor design, analysis, and modeling and simulations.

Scope and methodology

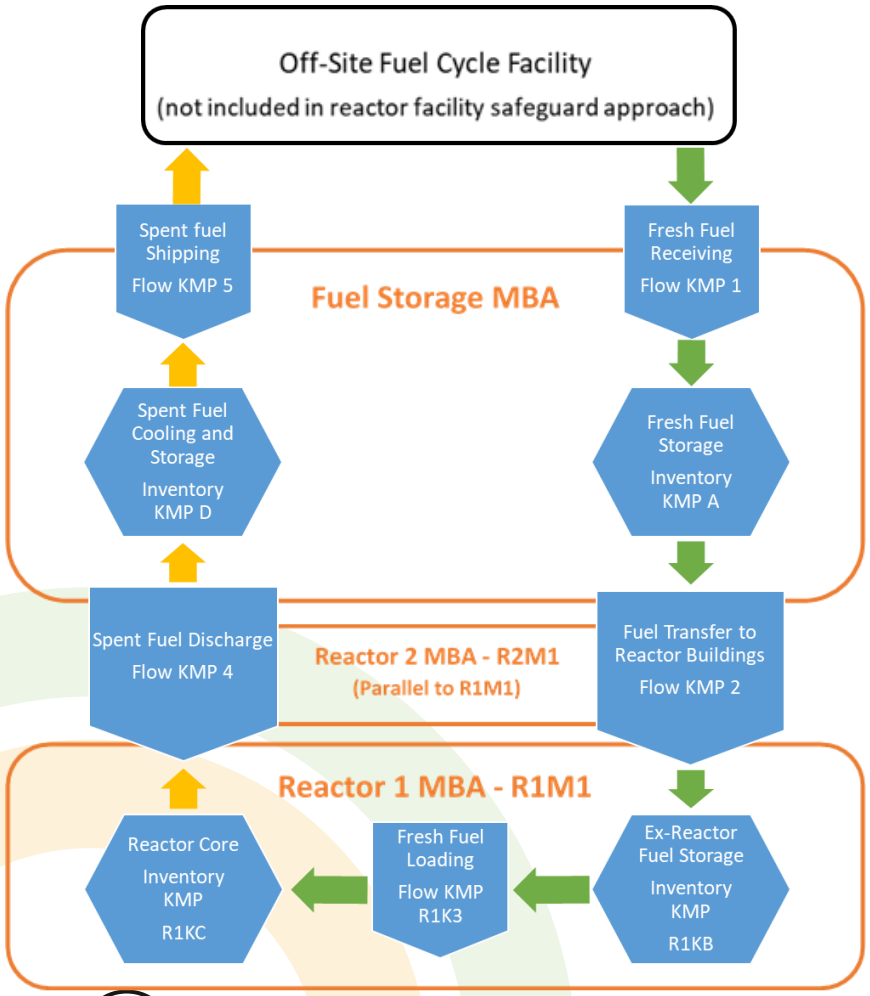
- Scope of Work
  - Any new non-light water reactor concept, less than 30 Mwe.
  - Reactor concepts currently in demonstration phase.
  - Focused only on the reactor facility and surroundings for domestic safeguards.
  - All design features that would influence safeguards (safety-crosswalk).
- Methodology
  - Examine current Material Control and Accountancy (MC&A) and Physical Security & Physical Protection (PSPP) practices.
  - Assess assumptions for each concept and safeguards applications.
  - Map practices to advanced reactors (microreactors especially).
  - Use “Outside-In” approach to MC&A and PSPP analysis.
  - Document identified gaps and strengths as a generic decision matrix.
  - Perform Analytical Assessments and Mod/Sim specific to the matrix.

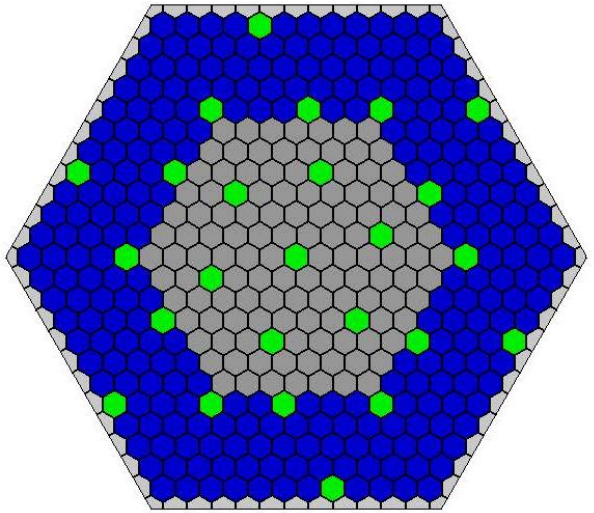
Material Control and Accountancy

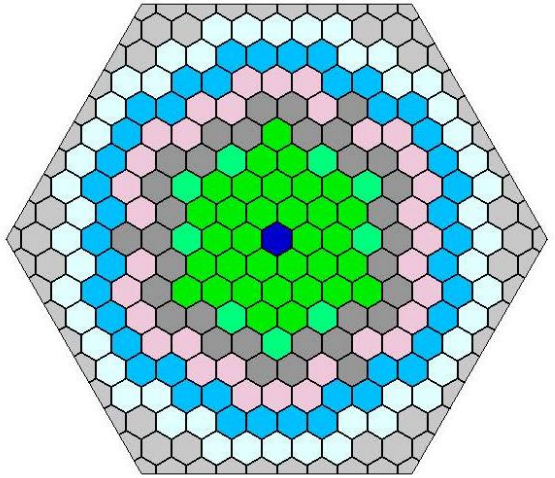
- The material control and accountancy (MC&A) for microreactors will depend very much on how the reactor will receive, transfer, arrange, eject, and cool fuel.
- The microreactor concepts all rely on reducing the number of fuel “items”.
- If it can be demonstrated that reliable accounting, recordkeeping, 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.



Material Control and Accountancy







- Calculations suggest that material control and accountancy (MC&A) for microreactors, using conventional practices adapted to microreactors, does not need significant changes to meet requirements.
- Burn-up confidence is high, experiments to confirm calculations might be a smaller effort.
- HALEU does not seem to affect the implications of the MC&A approaches adapted.

“Outside-In” approach to Material Control and Accountancy and Physical Security & Physical Protection 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 orange box represents a layer of “protection” where the purple is the target area or objective.