UCS Perspectives on Advanced Reactor Regulatory and Policy Issues

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What is an “advanced reactor”?

- NRC has not adopted a consistent definition for the term “advanced reactor”—this is problematic
- “This regulatory basis recognizes that the phrase ‘advanced reactors’ has different meanings in different documents …” -- Draft Regulatory Basis, Rulemaking for Physical Security for Advanced Reactors, July 2019
  - Physical Security Regulatory Basis: “Light-water small modular reactors and non-light-water reactors”
    - could include large CANDUs
  - 2008 Advanced Reactor Policy Statement: any design other than an LWR licensed before 1997
    - could include large LWRs (AP1000)
- In any case, these definitions do not include the NRC’s enhanced safety and security expectations in the Advanced Reactor Policy Statement

NEIMA’s definition

- More refined (but also problematic) definition in the Nuclear Energy Innovation and Modernization Act:

  “…a fission …or fusion reactor … with significant improvements compared to commercial nuclear reactors under construction as of …” January 14, 2019 (date of enactment), including improvements such as—

  (A) additional inherent safety features;

  (B) significantly lower levelized cost of electricity;

  (C) lower waste yields;

  (D) greater fuel utilization;

  (E) enhanced reliability;

  (F) increased proliferation resistance;

  (G) increased thermal efficiency; or

  (H) ability to integrate into electric and nonelectric applications.

NRC's NEIMA obligations

- [NRC] shall develop and implement, **where appropriate**, strategies for the increased use of risk-informed, performance-based licensing evaluation techniques and guidance for commercial advanced nuclear reactors within the existing regulatory framework"
  - Gives the NRC full discretion to determine where such strategies are "appropriate" but limits application to reactors "with significant improvements" compared to the AP1000
- However, NEIMA does not make clear if this definition applies to reactors that have both significant improvements and significant disadvantages compared to current commercial reactors
  - Non-LWRs will generally have some improvements and some disadvantages compared to LWRs
- Nor does it specify how the NRC should make such determinations

Common-cause failure

- The proposed framework for risk-informing advanced reactors lacks defense-in-depth because the accuracy of the probabilistic risk assessment (PRA) is a common-cause failure mode
- PRAs for non-LWR designs are largely academic exercises and lack sufficient data for validation
- The PRA (with mechanistic source term) may be used to justify
  - Siting in densely populated urban areas
  - Elimination of off-site radiological emergency planning
  - Reduction in number of armed responders
  - Reduction in number of operators
  - No containment structure
  - No safety-related electrical power
  - Reduction in NRC oversight
- What is the cumulative impact of these regulatory rollbacks?

Acceptance review

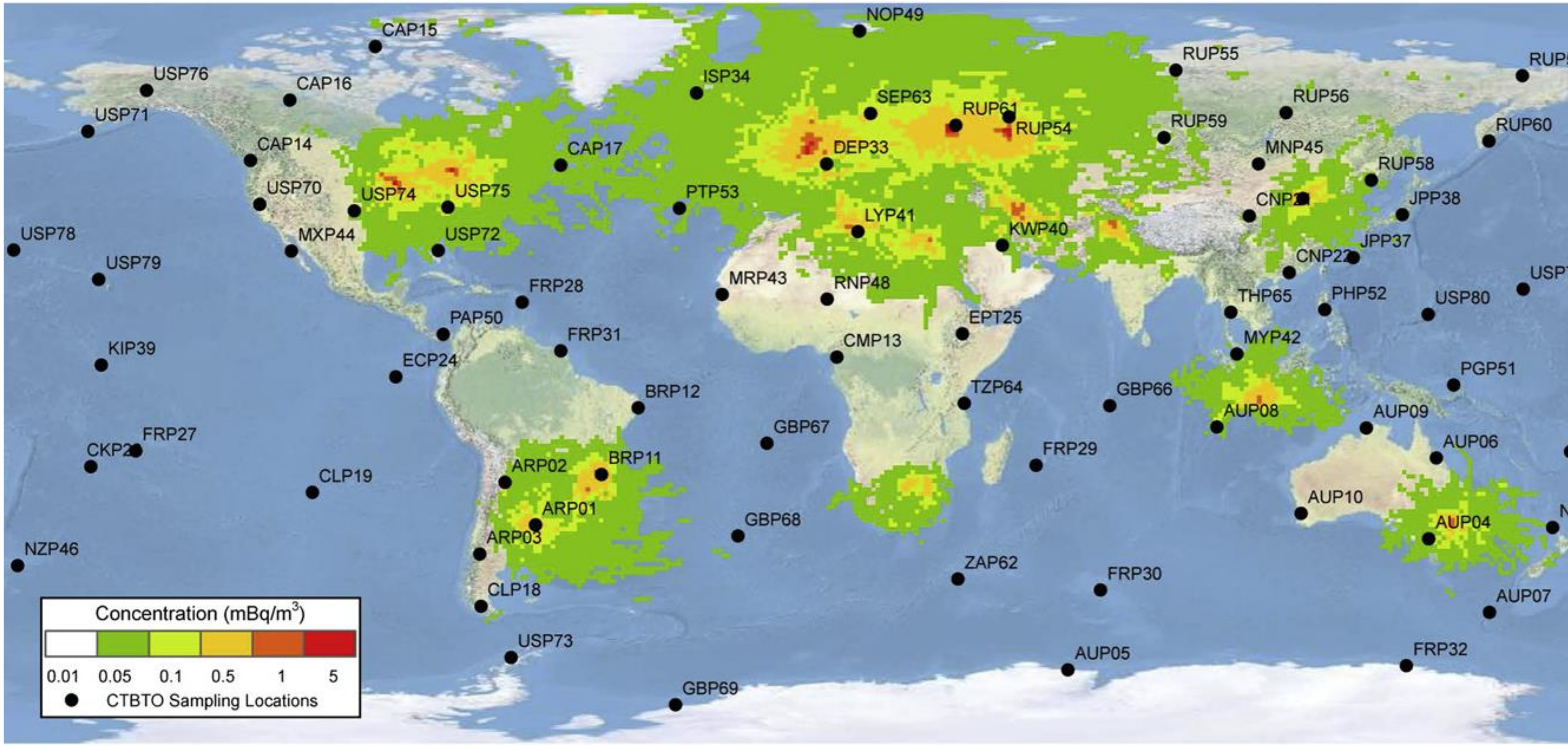
- Staff have proposed that the required content of non-LWR applications and the level of detail of NRC's review themselves be "risk-informed"—that is, also based on the PRA
- This could lead to circular reasoning: systems, structures and components (SSCs) that the applicant asserts are less risk-significant would receive less review, making it more difficult for staff to determine if the SSCs were properly classified in the first place
- NRC should develop acceptance criteria that new reactor applicants would have to meet to enable independent confirmation that their designs are likely to be significantly safer and more secure *before* allowing them to use risk-informed licensing processes

Changing urban siting policy

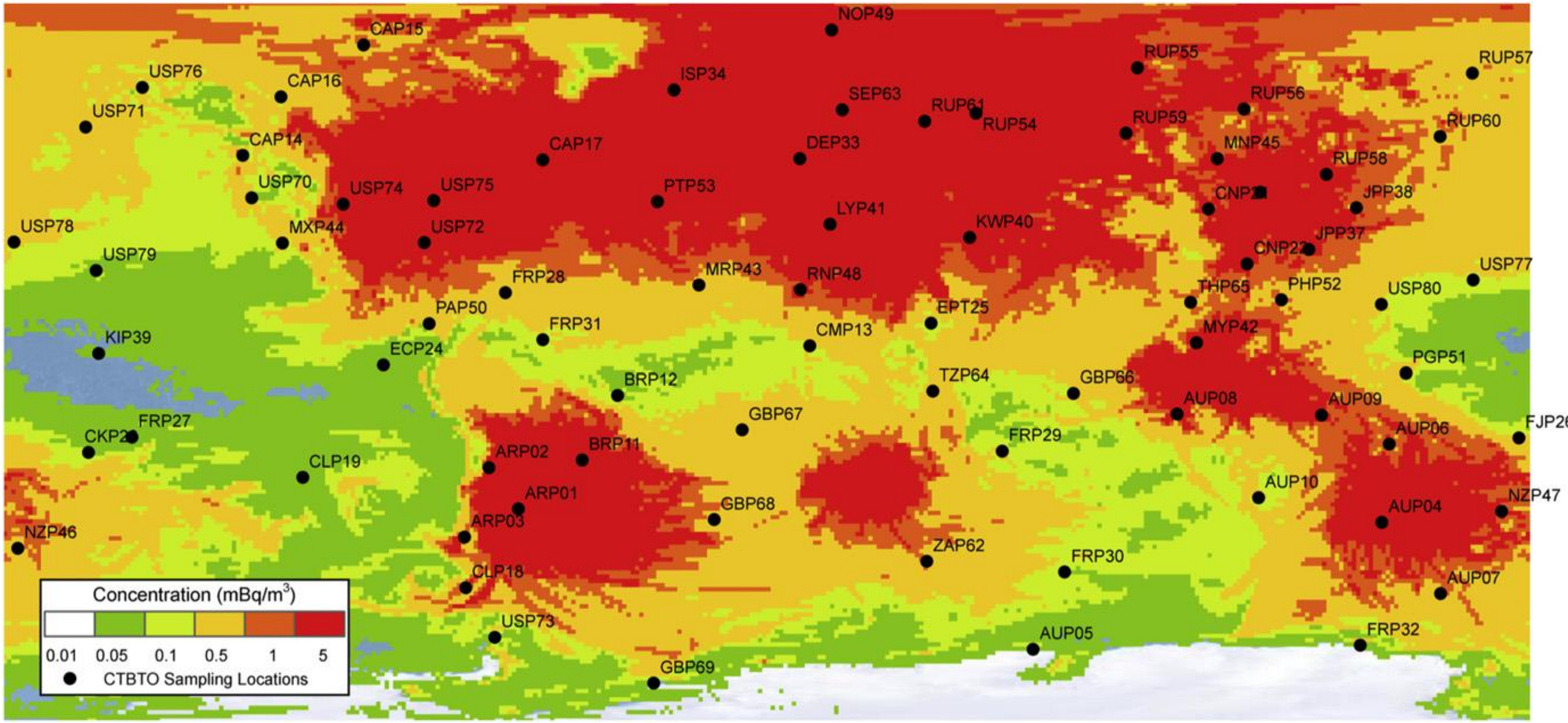
- UCS does not support the staff's proposed changes to longstanding NRC policy to allow siting of "advanced" reactors in densely populated areas—and certainly not through a mere change to a regulatory guide
- Changes to siting policy should not be based only on individual risk limits but also technically sound societal risk metrics
  - Land contamination/relocation standard
  - Population dose limit
- "… a power plant could be located in Central Park and still meet the Commission's quantitative offsite release standard." – Separate Views of Commissioner Bernthal on Safety Goals Policy, 1986
- Any such changes would be of great consequence and should occur only through rulemaking

Example of a less safe “advanced” reactor: the MSR

- One of the advantages of the molten salt-fueled reactor (MSR) is the flexibility provided by a circulating liquid fuel
- Noble gas fission products are stripped from the fuel by sparging with helium gas
- MSR vendors assert that they will be able to trap and retain noble gas fission products
  - few details provided on the specifications, practicality, efficiency, reliability, and cost of off-gas processing systems
- Xenon (Xe) releases from MSRs could pose problems not only for public health and safety, but for Comprehensive Test Ban Treaty verification
- 40 to 90 percent of cesium-137 generated would be released from the core into the off-gas system under NORMAL conditions



Global maximum calculated concentration of ^{133}Xe expected emission from current isotope producers, assuming releases of $5x10^9$ Bq/day (T.W. Bowyer et al., *Journal of Environmental Radioactivity* 115 (2013) 192-200)



Global maximum calculated concentration of ^{133}Xe expected emission from current and future isotope producers, assuming releases of 1×10^{12} Bq/day (T.W. Bowyer et al., *Journal of Environmental Radioactivity* 115 (2013) 192-200)

Controlling the xenon background

- Unacceptable IMS interference occurs at Xe emission levels below those needed to meet safety limits
- A seminal study determined that a maximum average Xe-133 emission rate of **$5x10^9$ Becquerels/day (0.14 curies/day) per facility** would be adequate to control the problem
- 400 MW_{th} Terrestrial Energy molten salt reactor would generate $1x10^{17}$ becquerels/day of ^{133}Xe
  - Source term is seven orders of magnitude greater than the $5x10^9$ Bq/day level
- The NRC should require MSRs to comply with this limit (or a technically justified alternative)
  - Jeopardizing CTBT verification would be “inimical to the common defense and security”

Acronyms

- **MSR: Molten-Salt [Fueled] Reactor**
- **NEIMA: Nuclear Energy Innovation and Modernization Act**
- **PRA: Probabilistic Risk Assessment**
- **SSC: Structures, Systems, and Components**
- **UCS: Union of Concerned Scientists**