SCHEDULING NOTE

Title: **BRIEFING ON ADVANCED REACTORS AND NEW REACTOR TOPICS (Public)**

Purpose: To provide the Commission with an update on (1) NRC's efforts to modernize and risk-inform regulatory processes to effectively and efficiently license advanced reactors, (2) the NRC's efforts to complete the regulatory readiness activities under the Nuclear Energy Innovation and Modernization Act (3) Vogtle project activities, and (4) stakeholder perspectives on advanced reactor industry initiatives and NRC developmental activities, including potential policy and program challenges.

Scheduled: **February 6, 2020**
9:00 a.m.

Duration: Approx. 3 hours

Location: Commissioners' Conference Room, 1st fl. OWFN

Participants: **Presentation**

Panel 1 – External Stakeholders **40 mins.***

Alice Caponiti, Deputy Assistant Secretary, Office of Nuclear Fleet and Advanced Reactor Development, U.S. Department of Energy — 10 mins.*

Topic:

- DOE perspectives on advanced reactor development, including Development and application of technology-inclusive, risk-informed, and performance-based methodologies

Doug True, Chief Nuclear Officer and Senior Vice President, Nuclear Energy Institute — 10 mins.*

Topic:

- Nuclear industry initiatives and priorities to support advanced reactor deployment including efforts on micro-reactors
- Status of NEI advanced reactor technology work groups (high temperature gas, fast reactors and molten salt reactors)

Amir Afzali, Policy and Licensing Director - Next Generation Reactors, Southern Company Services — 10 mins.*

Topic:

- Licensing Modernization Project efforts to develop technology-inclusive, risk-informed, and performance-based guidance for licensing advanced reactors
- Insights and lessons-learned from pilot applications

Edwin Lyman, Director of Nuclear Power Safety, Union of Concerned Scientists — 10 mins.*

Topic:

- Stakeholder perspectives on advanced reactor regulatory and policy issues

Commission Q & A — **40 mins.**

Break — **5 mins.**

Panel 2 - NRC Staff — **40 mins.***

Margaret Doane, Executive Director for Operations

Topic:

- Opening Remarks

Robert Taylor, Deputy Director for New Reactors, NRR

Topic:

- Vision and direction for regulatory reviews of advanced reactors, key opportunities and challenges, and coordination with federal agencies and external stakeholders

Mike King, Director, Voglte Project Office, NRR

Topic:

- Vogtle project activities

John Segala, Branch Chief, Advanced Reactor Policy Branch, Division of Advanced Reactors and Non-Power Production and Utilization Facilities, NRR

Topic:

- Licensing Modernization Project
  - Endorsement of guidance for a technology-neutral, risk-informed, and performance-based approach to licensing, and activities to meet NEIMA requirements

Ben Beasley, Branch Chief, Advanced Reactor Licensing Branch, Division of Advanced Reactors and Non-Power Production and Utilization Facilities, NRR

Topic:

- Overview of readiness to review license applications, status of applications, and development of safety and environmental review regulatory guidance

Commission Q & A — **40 mins.**

Discussion – Wrap-up — **5 mins.**

* For presentation only and does not include time for Commission Q & A's

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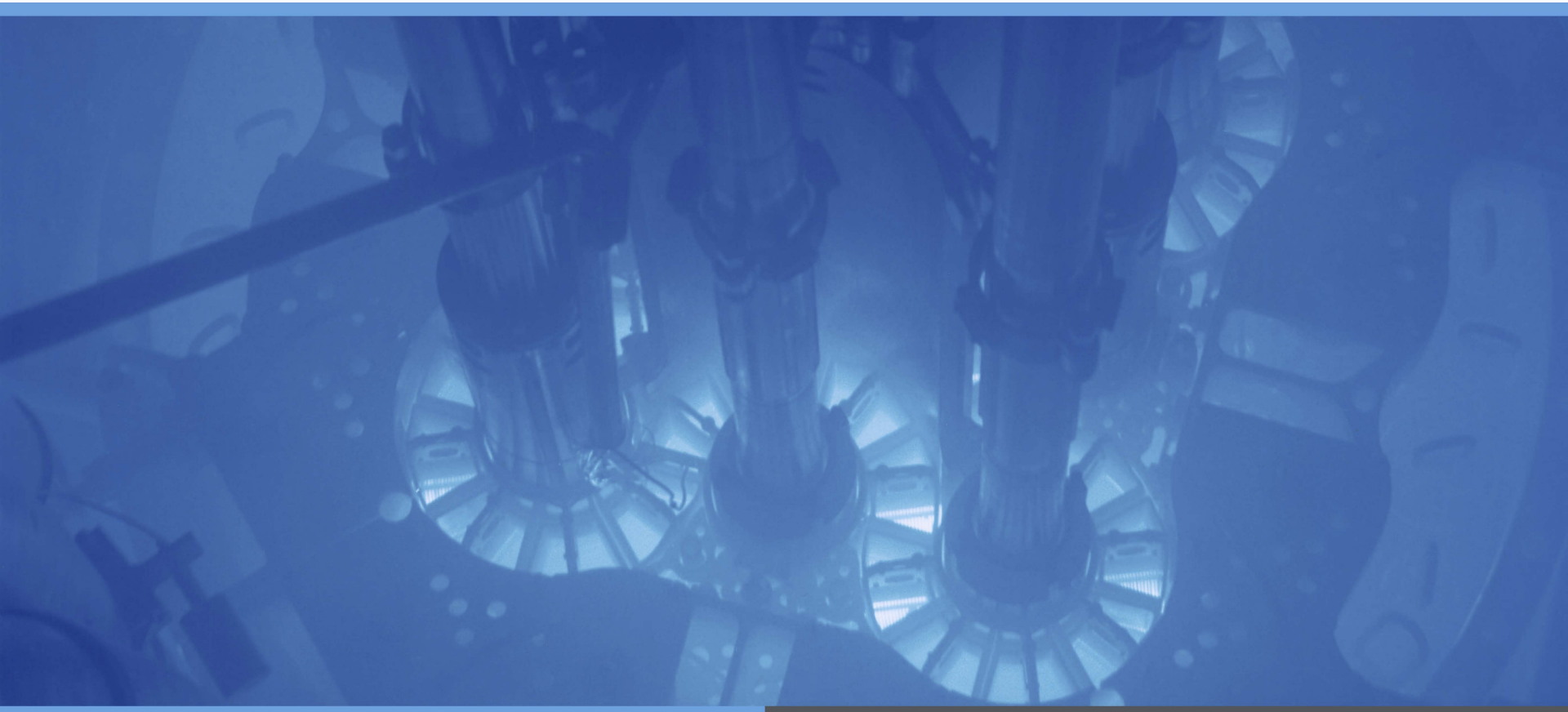
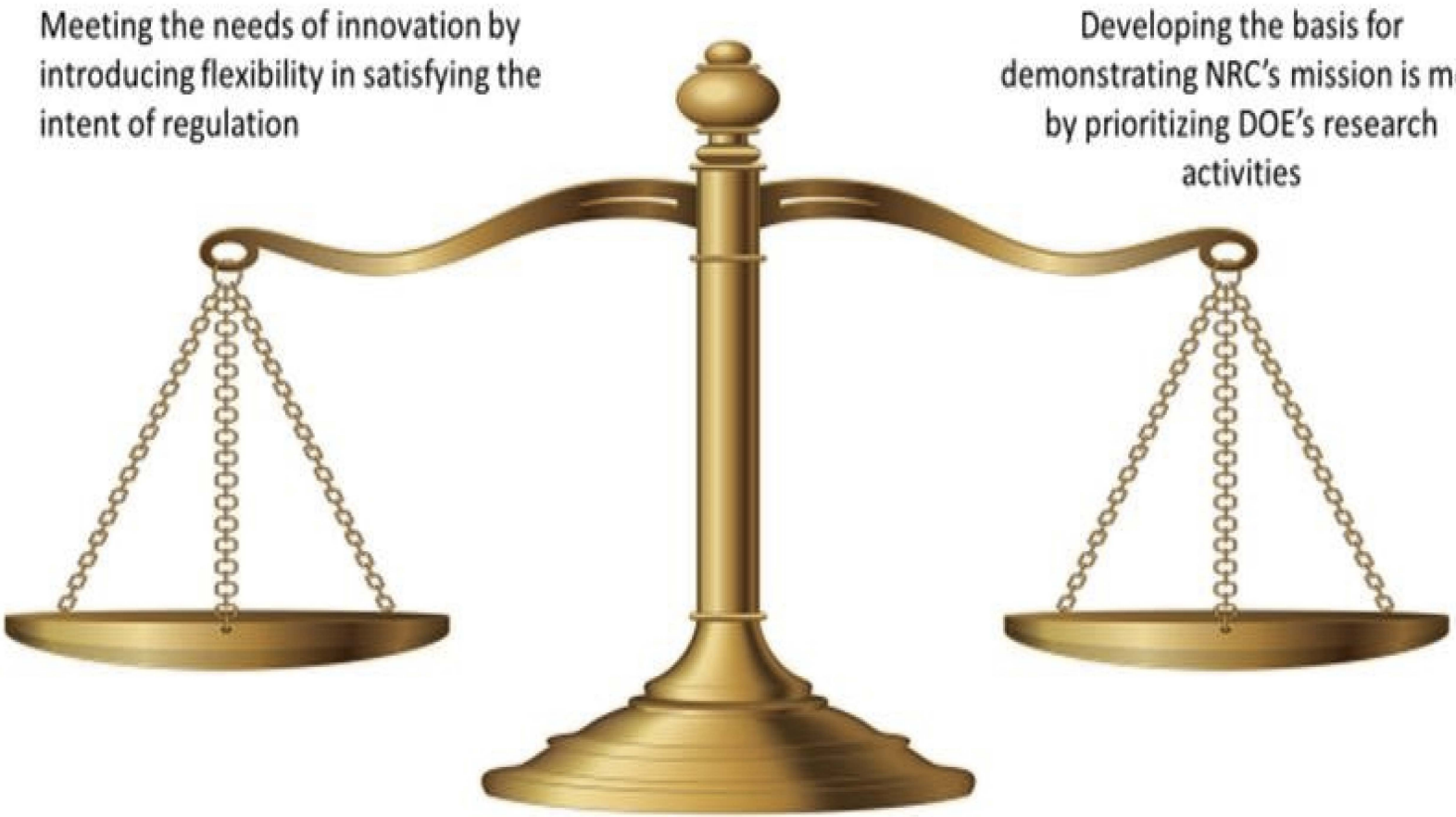


DOE Perspectives on Advanced Reactor Development and Licensing

Alice Caponiti
Deputy Assistant Secretary for
Reactor Fleet & Advanced Reactor Deployment
Office of Nuclear Energy
U.S. Department of Energy

DOE Technology Inclusive Initiatives Can Expedite the Retirement of Regulatory Risk While Modernizing the Regulatory Framework



Why is DOE Interested in Assuring a Risk-Informed Performance Based (RIPB) Approach to Advanced Reactor Licensing ?

- **Reactor plant event sequence identification, evaluation, and safety system classification are a key source of regulatory uncertainty impeding advanced reactor deployment**
- **Difficult to consistently and confidently address uncertainty through a purely "ad-hoc" and expert judgment-based approach due to:**
  - Wide variation in reactor technologies and safety case approaches
  - Financial uncertainty created by late-stage and less structured regulatory decisions
- **RIPB approach is technology-inclusive and can be applied to the broad range of advanced reactor designs being supported by DOE**
- **Assists industry stakeholders and DOE in identifying vulnerabilities and uncertainties and focus research efforts in the most impactful areas**

DOE Has a History of Promoting Risk-Informed Performance Based (RIPB) Methodologies

- **Directly and consistently supported RIPB approaches to the design and licensing of advanced reactor technologies since the 1980's**
  - General Atomics
  - Exelon - Pebble Bed Modular Reactor
  - Next Generation Nuclear Plant (NGNP)
  - Licensing Modernization Project (LMP)
  - LMP Pilot Studies on a variety of designs

- **Efforts resulted in the approach now being considered by the Commission**
  - Per the Advisory Committee on Reactor Safeguards (ACRS), RIPB approach reflects the culmination of DOE, NRC and industry insights and "good practices"

- **Strong partnerships and focus on RIPB methodologies continue between the private sector and Government**

RIPB Approach Going Forward

- **Ongoing DOE projects, are implementing the RIPB approach developed through the LMP in support of the DOE authorization process**
- **Continue DOE cost-shared initiatives addressing licensing (TICAP) and individual awards to industry**
- **Promote advanced reactor regulatory efficiency by assisting industry in developing NRC application development**
- **Continue collaborations with the international community on advanced reactor technologies**

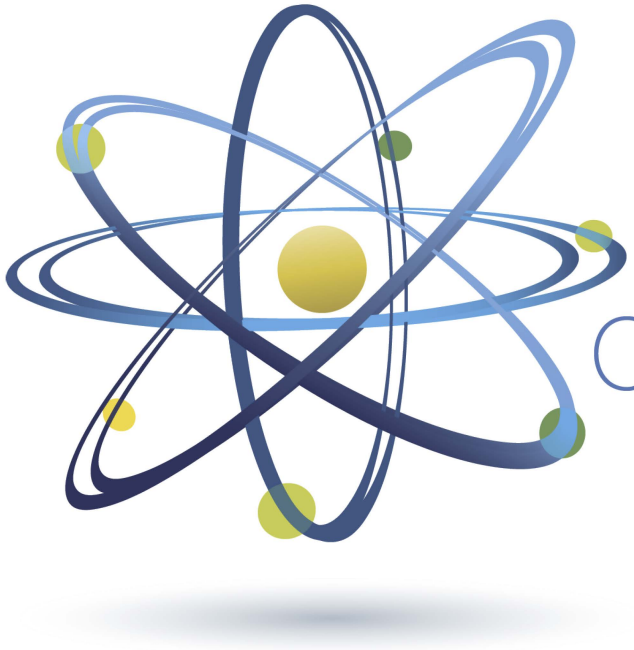
NRC Coordination & Engagement

- **Joint advanced reactor deployment activities (LMP, TICAP)**
- **Nuclear Energy Institute Advanced Reactor Working Group and Technology-Specific Technical Working Groups**
- **Ongoing NRC-DOE partnerships to evaluate emerging technologies**

Ongoing and Planned DOE Advanced Reactor Development and Deployment Efforts

- **Advanced Reactor Technologies (ART) Program National Laboratory R&D Activities**
- **Versatile Test Reactor**
- **Advanced Reactor Demonstration Program**
  - ***National Reactor Innovation Center (NRIC)***
  - ***Advanced Reactor Demonstrations***
  - ***Risk Reduction for Future Demonstrations***
  - ***Regulatory Development***
  - ***Advanced Reactor Safeguards***
- **ARC-20 Awards**
- **Industry Funding Opportunity Announcement Awards**

Questions?



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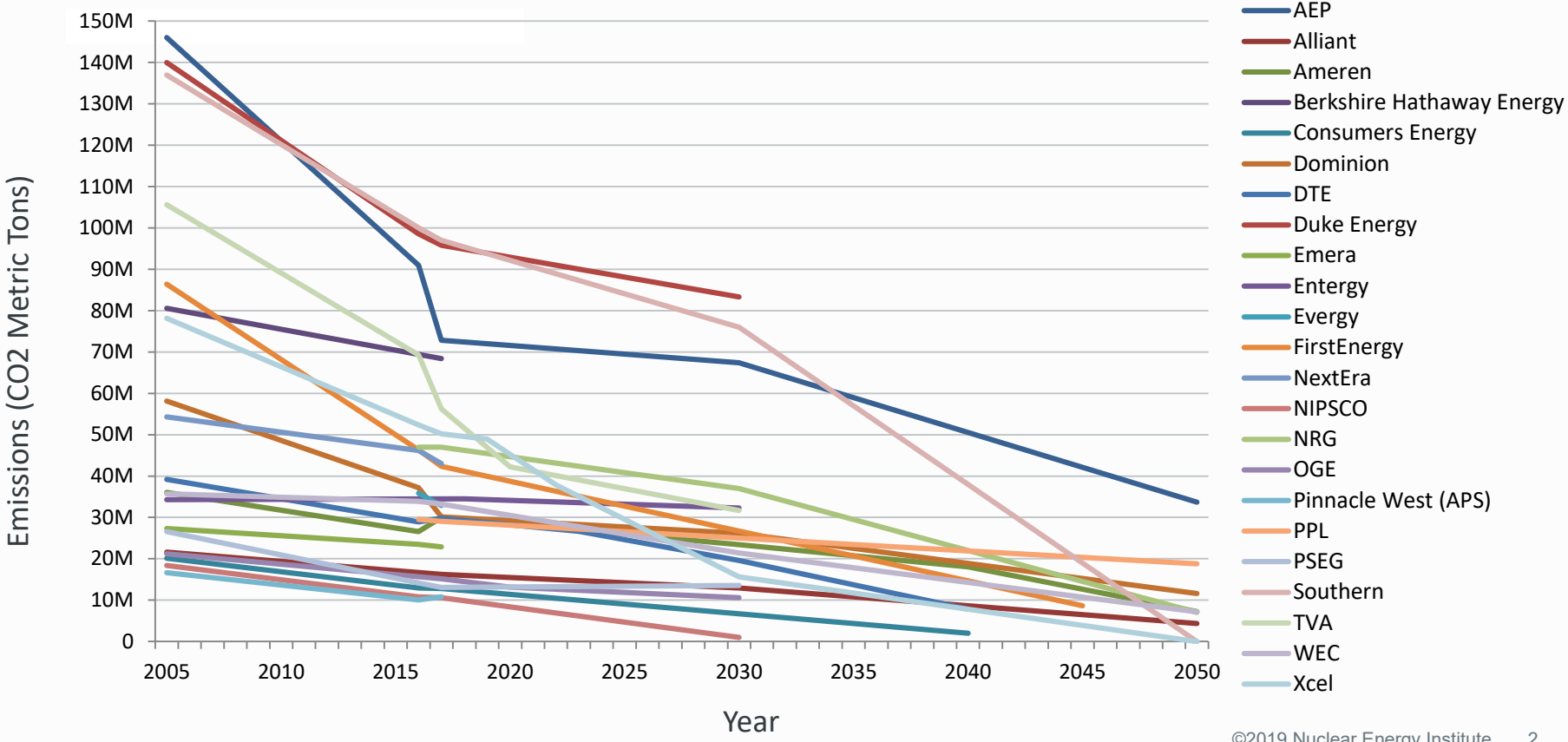
New & Advanced Reactors

Doug True
Chief Nuclear Officer and Senior Vice President

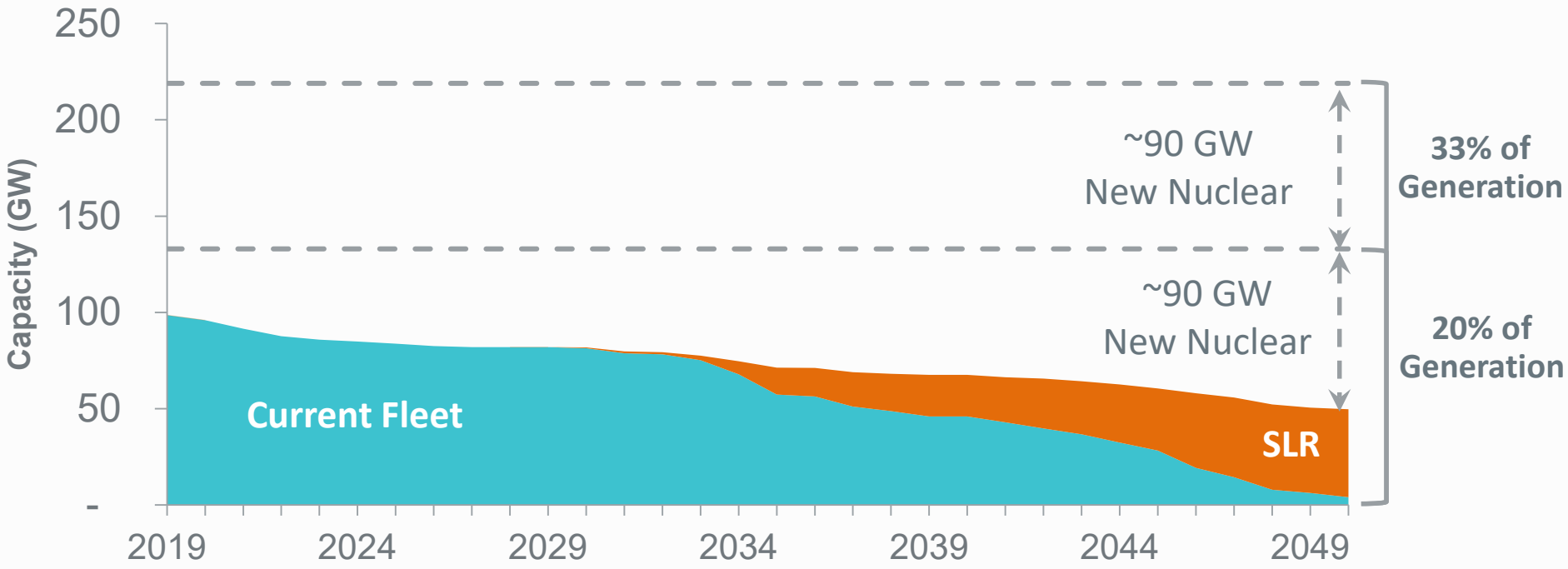
February 6, 2020

NUCLEAR ENERGY INSTITUTE

Decarbonization Trajectory of U.S. Utilities



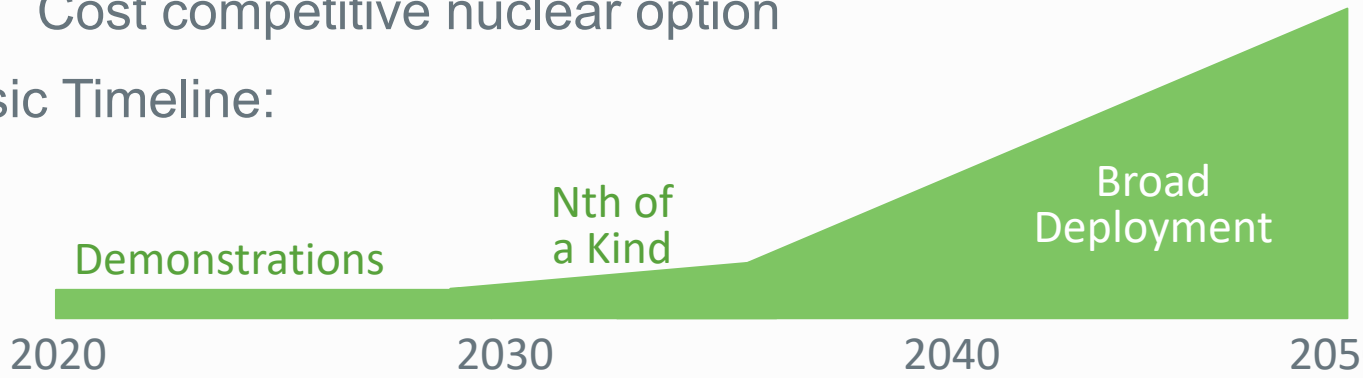
Nuclear's Role in a Low Carbon Electricity Future



Does not account for decarbonization of other sectors

The Time is Actually Now

- Achievement of Carbon Goals Won't Happen Overnight
- Renewable Share Will Grow, but is Limited
  - Even with storage
- Firm, Dispatchable Power Still Needed
  - Utilities making decisions today about conversions from coal
  - Cost competitive nuclear option
- Basic Timeline:



Regulatory Priorities

1. Construction and licensing decisions
   - Vogtle 3 and 4
   - Design and site applications
2. Advanced reactor policy decisions
   - Risk-informed regulatory framework
   - Technology inclusive
3. Streamlining processes
   - Significantly shorter reviews
   - Efficient Environmental review

Licensing Modernization Project (LMP)

Amir Afzali
Licensing and Policy Director
Southern Company

Licensing Modernization Project

Why: Reduce regulatory uncertainty to enable accelerated commercialization of advanced non-LWR reactors

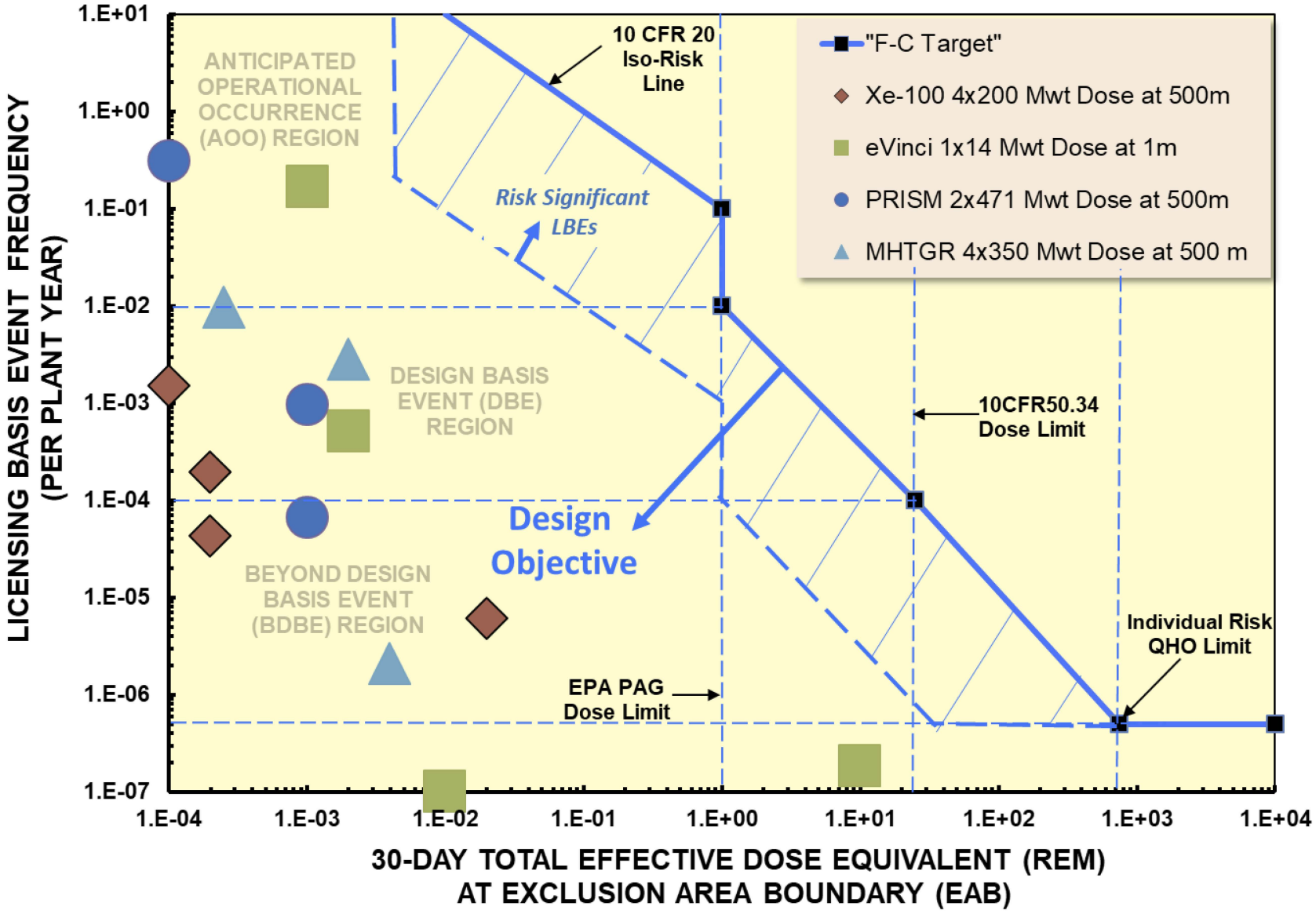
- Consistent with the Commission's long-standing effort to transition to risk-informed, performance-based regulations
- Key to achieving modern risk-informed regulation as envisioned in the agency's Transformation Initiative.

How: Develop transparent, systematic, risk-informed, performance-based, and predictable methodology

What: NEI 18-04 and four supporting reports are intended to:

- Select and evaluate Licensing Basis Events (LBEs)
- Classify Structures, Systems and Components (SSCs) based on their holistic and realistic contribution to risk
- Determine Defense-in-Depth (DiD) adequacy

LBE Evaluation Chart



LMP Tabletop Insights

Results of the Tabletop exercises confirmed that:

- The LMP process can be effectively executed for a spectrum of different non-LWR concepts
- Design decisions can be optimized through an integrated and realistic analysis of the plant's response
- Information obtained through the LMP-based design evaluation can be used for building a strong operational risk management program

Summary

- The LMP methodology, presented in NEI 18-04, is developed based on:
  - over 20 years of industry interactions with the NRC staff on risk-informed regulatory approaches, including many public reviews and discussions
  - lessons learned from a number of industry tabletop exercises, covering different technologies and designs
- Positive support of Draft Guide-1353 which endorses NEI 18-04:
  - ACRS letter of support, following a number of meetings with the industry and NRC staff.
- Next steps:
  - **Critical**- Approval of SECY-19-0117
  - **Valuable**- NRC endorsement of ASME non-LWR PRA standard.

SECY-19-0117 key step in support of Commission's long-standing effort to transition to risk-informed, performance-based regulations and regulatory modernization

Acronyms

- LMP– Licensing Modernization Project
- NEI- Nuclear Energy Institute
- LBE- Licensing Basis Events
- DBE- Design Basis Events
- DBA- Design Basis Accidents
- BDBE- Beyond Design Basis Events
- DiD– Defense-in-Depth
- QHO- Quantitative Health Objective
- EPA– Environmental Protection Agency
- PAG– Protection Active Guide
- EAB- Exclusion Area Boundary
- Mwt- Megawatt Thermal
- F-C- Frequency-Consequence

UCS Perspectives on Advanced Reactor Regulatory and Policy Issues

February 6, 2020
Dr. Edwin Lyman
Director of Nuclear Power Safety
Climate and Energy Program
Union of Concerned Scientists

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

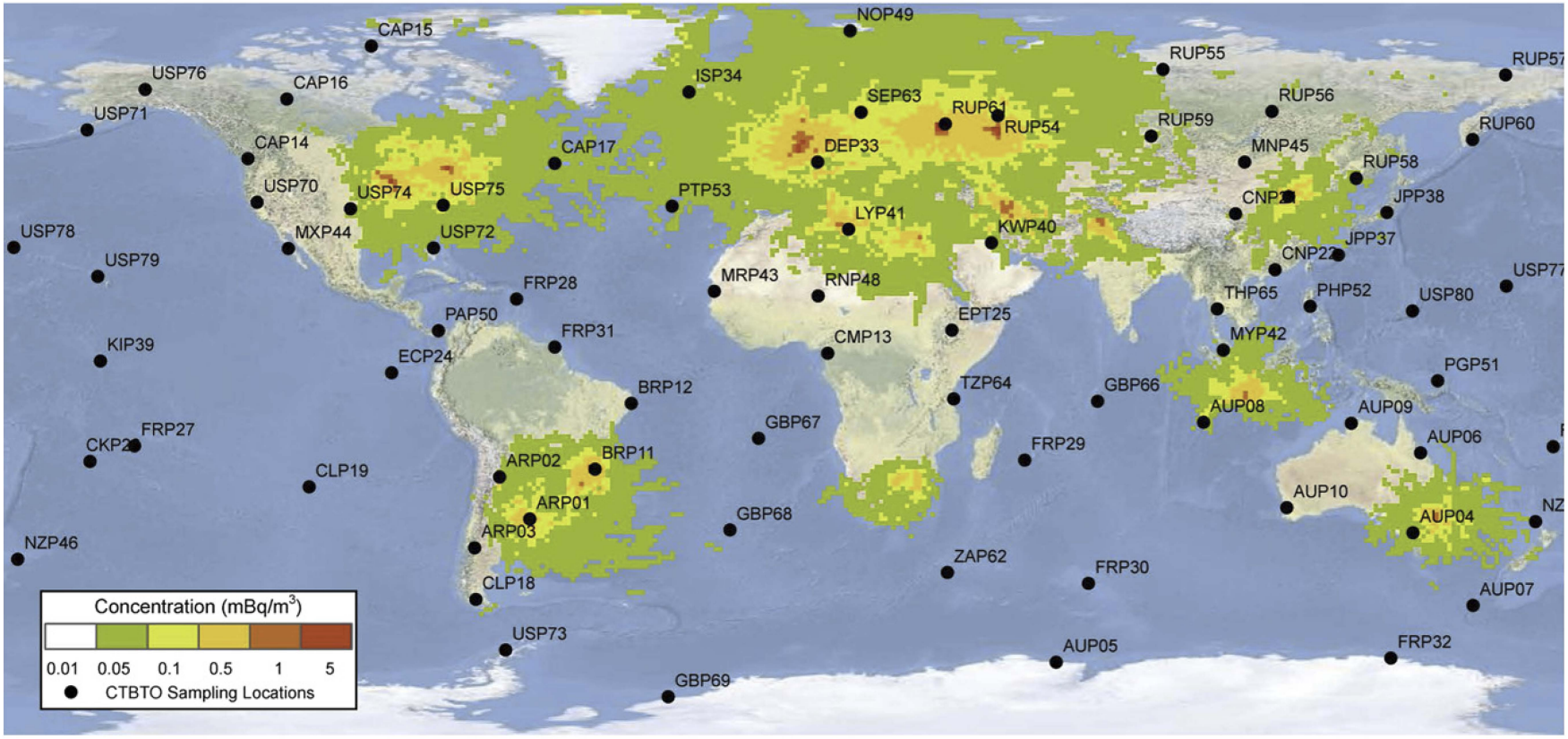
- Staff have proposed that the required content of non-LWR applications and the level of detail of NRC's review themselves be "risk-informed"—that is, also based on the PRA
- This could lead to circular reasoning: systems, structures and components (SSCs) that the applicant asserts are less risk-significant 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

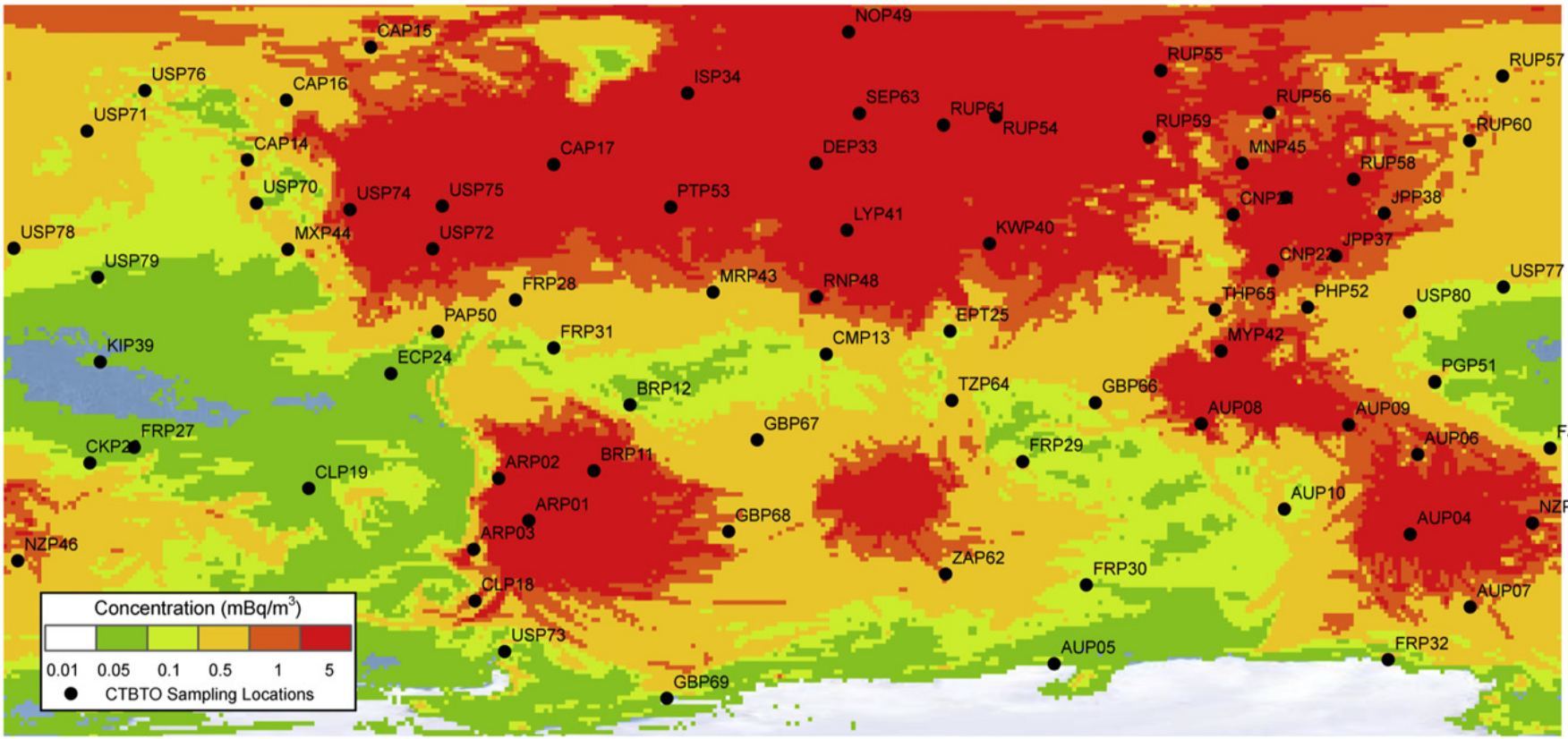
- UCS does not support the staff's proposed changes to longstanding NRC policy to allow siting of "advanced" reactors in densely populated areas—and certainly not through a mere change to a regulatory guide
- Changes to siting policy should not be based only on individual risk limits but also technically 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 $1x10^{12}$ 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**

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Advanced Reactors and New Reactors Topics Briefing

Commission Meeting

February 6, 2020



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Opening Remarks

Margaret Doane
Executive Director for Operations

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Vision and Direction for Regulatory Reviews of New and Advanced Reactors

Robert Taylor
Deputy Office Director for New Reactors

We Make SAFE Use of Nuclear Technology POSSIBLE

- ADVANCED REACTORS
- RESEARCH AND TEST REACTORS
- NEW REACTORS
- SUBSEQUENT LICENSE RENEWAL
- MEDICAL ISOTOPES
- OPERATING REACTORS

SAFE, TIMELY, AND EFFECTIVE LICENSING & OVERSIGHT OF VOGTLE 3&4

Photos Courtesy of Southern Nuclear Operating Company

Overseeing Vogtle Construction

Closing ITAAC

Resolving License Amendment Requests

SUSTAINING SMALL MODULAR REACTOR (SMR) PROGRESS

NUSCALE™

Design Certification on Schedule

Rulemaking

Phase 6

Phase 5

Phase 4 ✓

Phase 3 ✓

Phase 2 ✓

Phase 1 ✓

ON THE HORIZON

UAMPS
Utah Associated Municipal Power Systems

Combined License

NUSCALE™

Standard Design Approval

HITACHI

BWRX-300 SMR Construction Permit

ADVANCED REACTORS STAKEHOLDERS

Union of Concerned Scientists

CLEARPATH

NEA
NUCLEAR ENERGY AGENCY

THIRD WAY

OKLO

TerraPower

CNSC CCSN

IAEA
International Atomic Energy Agency

Kairos Power

TERRESTRIAL ENERGY

PUBLIC

Federal
State
Local

Southern Nuclear

NIC

Argonne NATIONAL LABORATORY

FEMA

NUCLEAR INNOVATION ALLIANCE

OAK RIDGE National Laboratory

Westinghouse

NEI

INL
Idaho National Laboratory

Sandia National Laboratories

Pacific Northwest NATIONAL LABORATORY

BROOKHAVEN NATIONAL LABORATORY

ENABLING the SAFE Use of New NUCLEAR Technologies

VOGTLE PROJECT OFFICE

Michael King, Director
Vogtle Project Office
Office of Nuclear Reactor Regulation

Photo Courtesy of Southern Nuclear Operating Company

Leveraging technology and innovation to ensure safe oversight of Vogtle project

Photos Courtesy of Southern Nuclear Operating Company

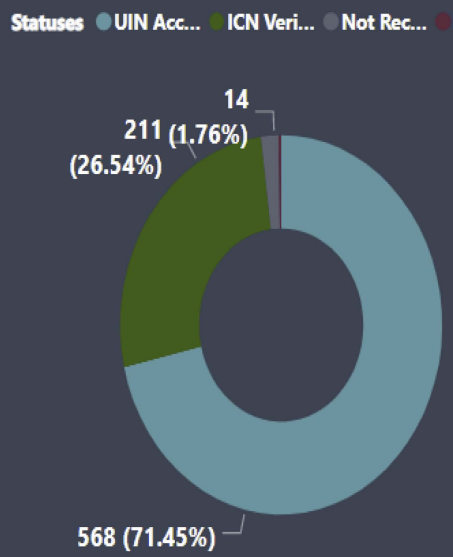
Vogtle Units 3 and 4 Dashboard

1/28/2020 8:42:25 AM

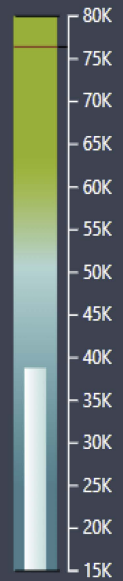
Last Refresh

ITAAC Inspection Progress

ITAAC Closure Notification Status



All Direct Inspection Hours



Days to All ITAAC Complete VOG3

300

Days to All ITAAC Complete VOG4

665

Top Focus Areas

- Inspection Inefficiencies
- Inspection Timeliness
- Late Filed Licensing Actions
- Late Filed Petitions
- Resident Site Infrastructure

NRC in the News

Open Licensing Actions

10

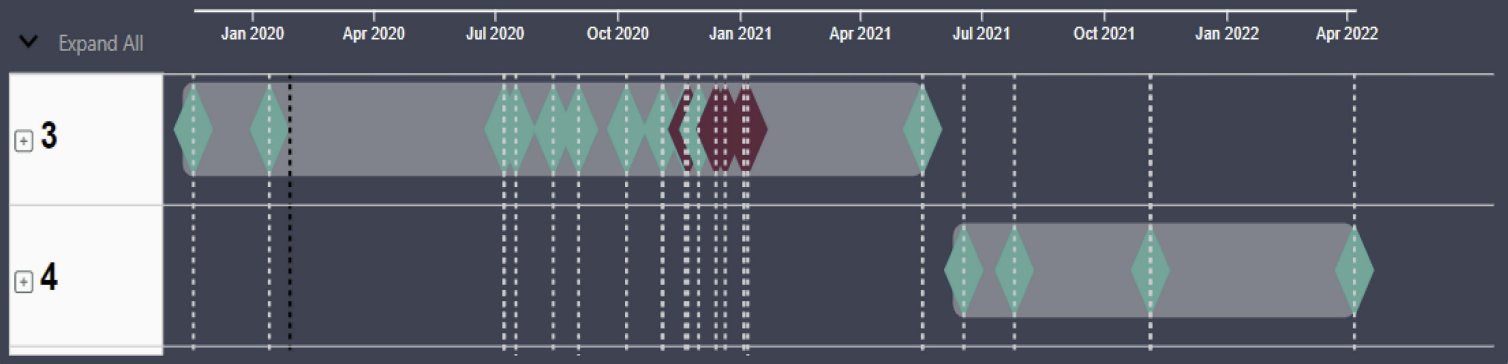
Open cROP Findings

1

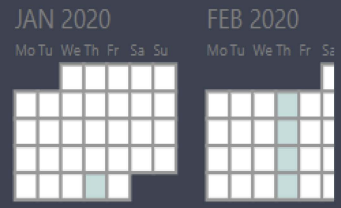
Indirect vs Direct (w Resident)

2.93

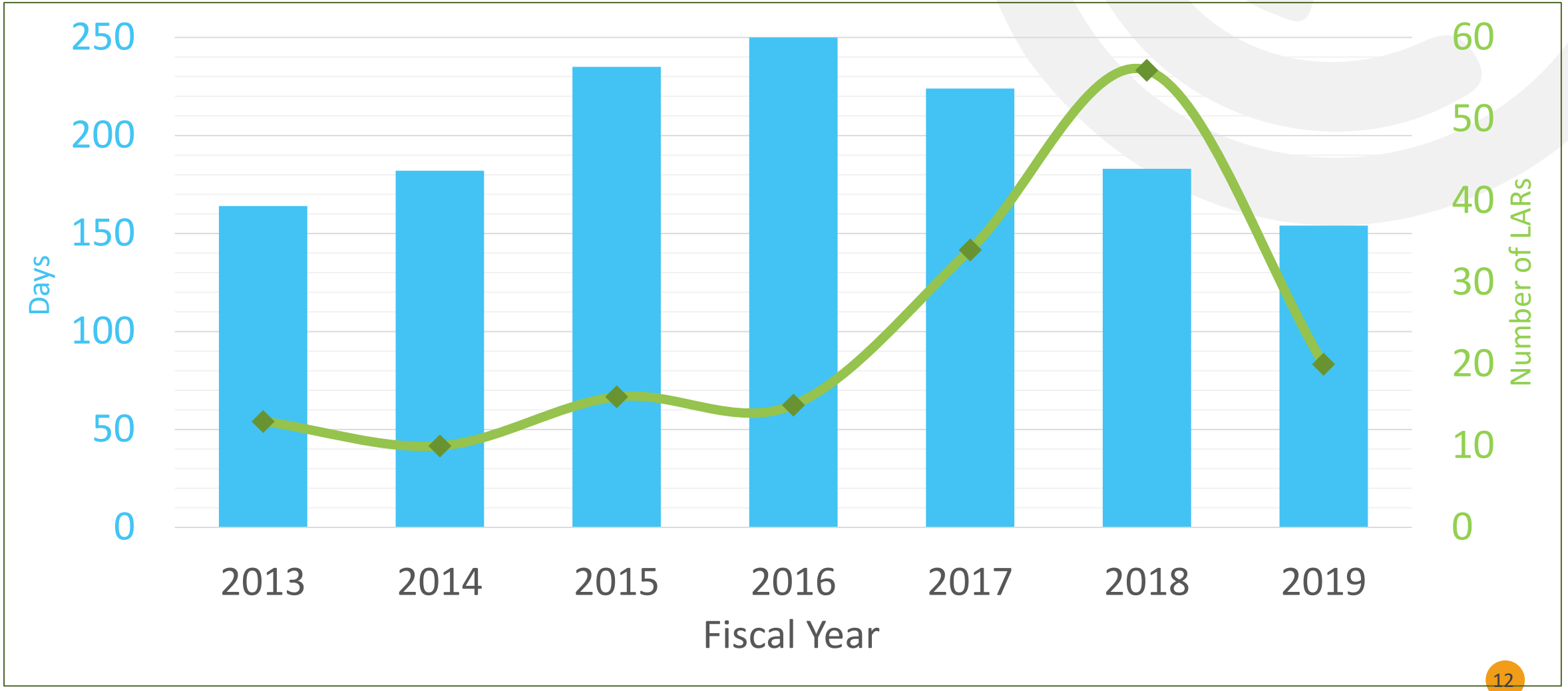
Vogtle Timeline



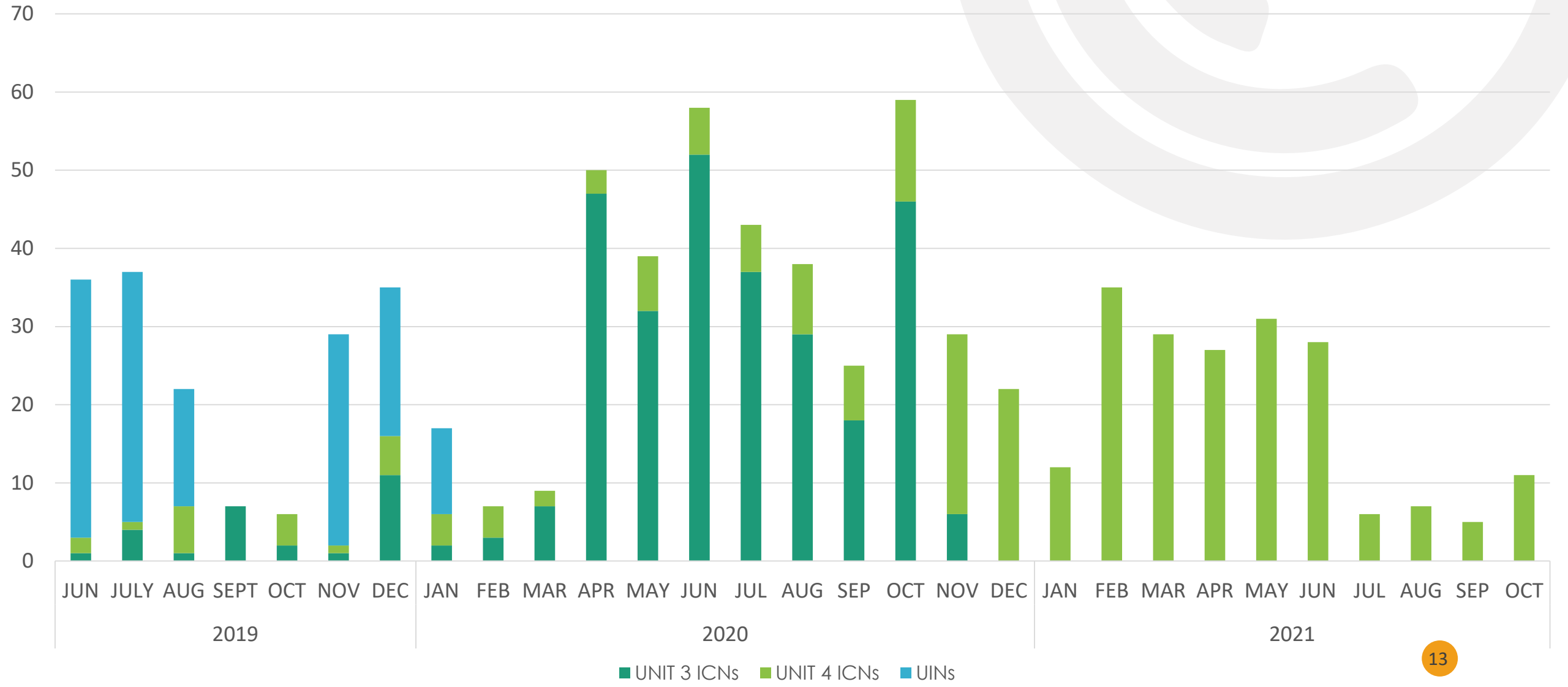
Public Meetings



Modern Risk-Informed Licensing for Faster Decision-Making



All Vogtle UINs Are Accepted Enabling Efficient ICN Reviews



Continuously Adapting Inspection to Incorporate Lessons Learned from First Part 52 Construction

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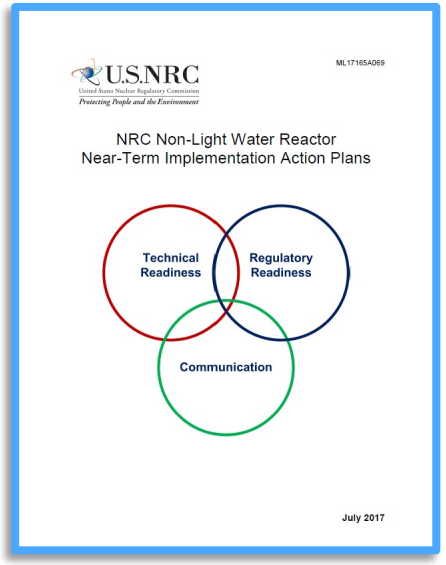
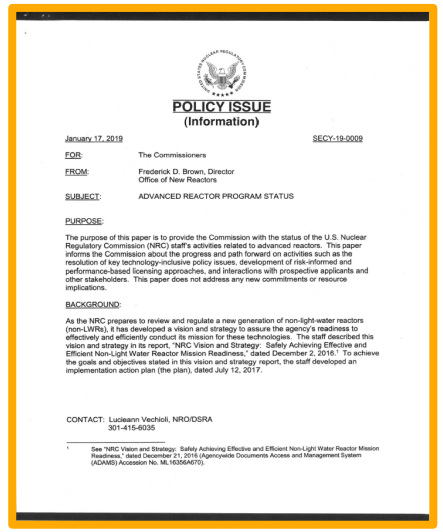
Initiatives to Modernize Advanced Reactor Licensing

John Segala

Chief, Advanced Reactor Policy Branch

Executing the Vision





POLICY ISSUE
(Information)

January 17, 2019 SECY-19-0009

FOR: The Commissioners

FROM: Frederick D. Brown, Director
Office of New Reactors

SUBJECT: ADVANCED REACTOR PROGRAM STATUS

PURPOSE:

The purpose of this paper is to provide the Commission with the status of the U.S. Nuclear Regulatory Commission (NRC) staff's activities related to advanced reactors. This paper informs the Commission about the progress and path forward on activities such as the resolution of key technology-inclusive policy issues, development of risk-informed and performance-based licensing approaches, and interactions with prospective applicants and other stakeholders. This paper does not address any new commitments or resource implications.

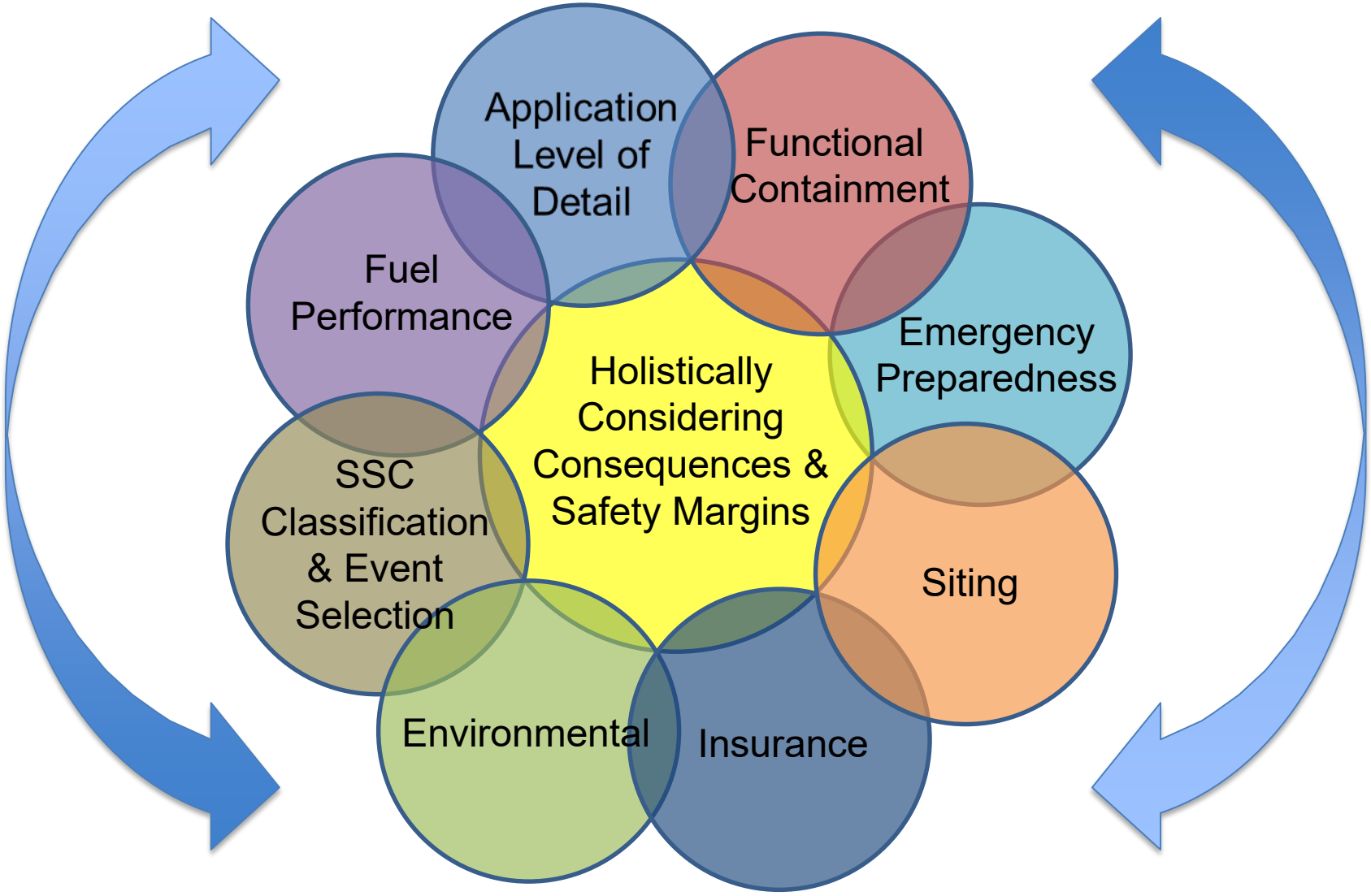
BACKGROUND:

As the NRC prepares to review and regulate a new generation of non-light-water reactors (non-LWRs), it has developed a vision and strategy to assure the agency's readiness to effectively and efficiently conduct its mission for these technologies. The staff described this vision and strategy in its report, "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness," dated December 2, 2016.[1] To achieve the goals and objectives stated in this vision and strategy report, the staff developed an implementation action plan (the plan), dated July 12, 2017.

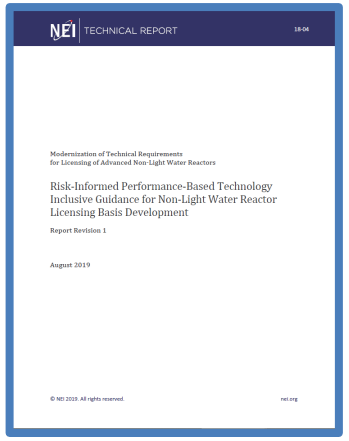
CONTACT: Lucieann Vechioli, NRO/DSRA
301-415-6035

[1] See "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness," dated December 21, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16356A670).

Facilitating Innovation with an Integrated Safety Approach

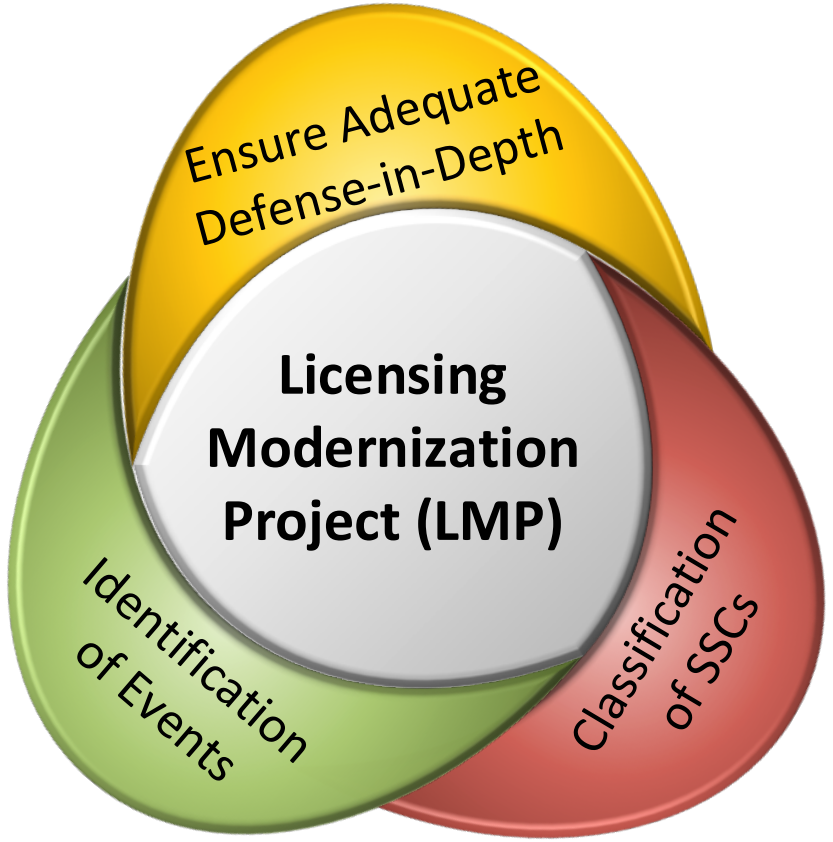


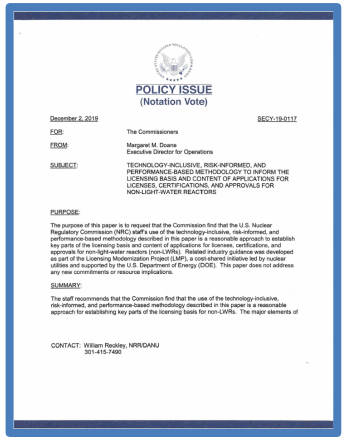
Developing a Modern Risk-Informed Framework



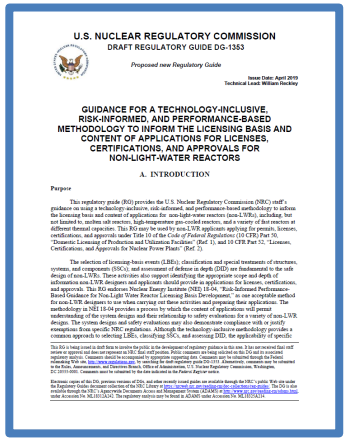
NEI-18-04

6 LMP Pilots



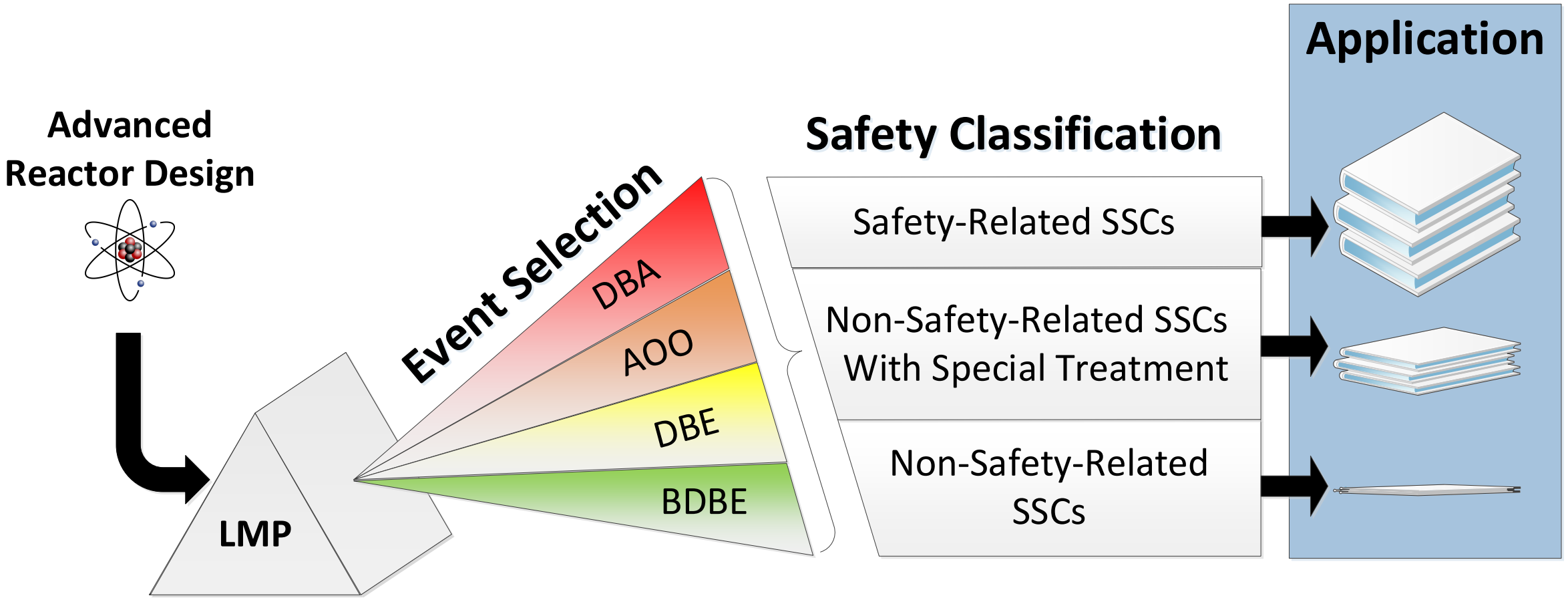


SECY-19-0117



DG-1353

Risk-Informing the Content of Applications



Cooperating Internationally

Memorandum of Cooperation with Canada

Working Group on the Safety of Advanced Reactors (WGSAR)

IAEA International Atomic Energy Agency

Sharing Regulatory Experience

Advancing Risk-Informed and Performance-Based Licensing Approaches

Implementing NEIMA Provisions

Nuclear Energy Innovation and Modernization Act (NEIMA)

- Issued Reports to Congress
  - Staged Licensing Process
  - Risk-Informed Guidance
- Developing Guidance within Existing Framework
  - Source Term
  - Event Selection
  - Containment Performance
  - Emergency Preparedness
- Developing a Technology-Inclusive, Risk-Informed and Performance-Based Regulatory Framework
  - 10 CFR Part 53

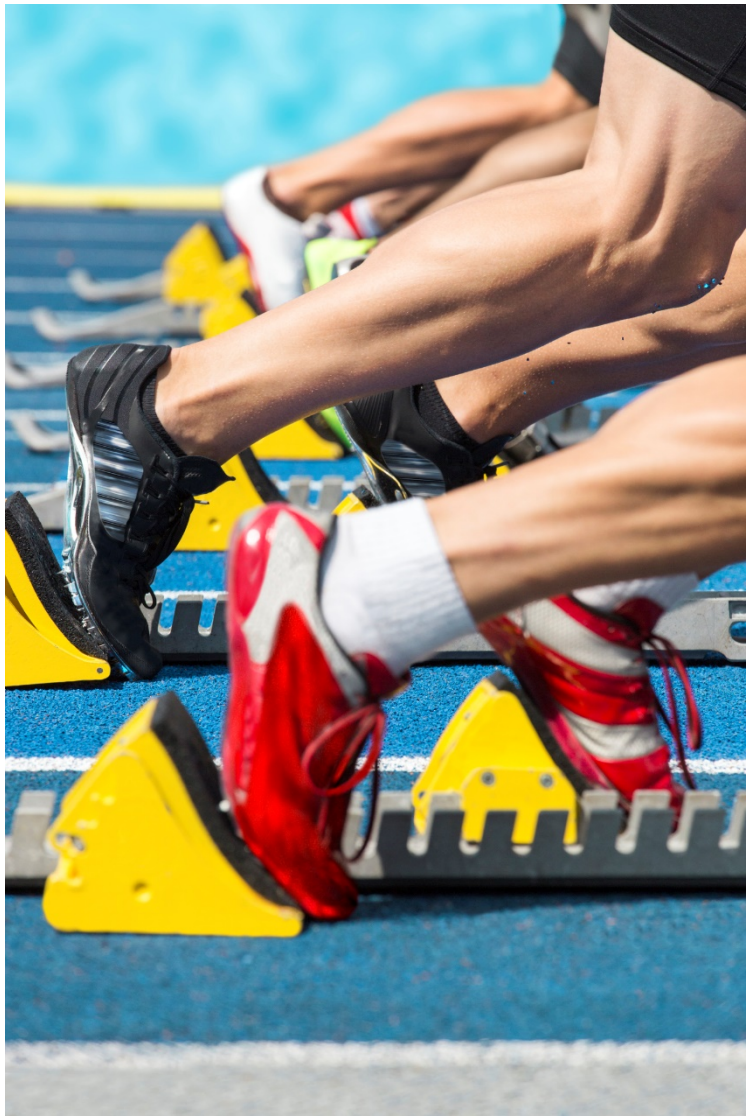
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Readiness to Review Non-LWR Applications

Ben Beasley, Chief
Advanced Reactor Licensing Branch

Readiness: Staff Preparations

- Guidance for industry
- Guidance for NRC Staff
- Training for NRC Staff



Readiness: New Approaches

- Pre-application interaction:
  - White paper, audit
  - Topical report, Preliminary Safety Information Document

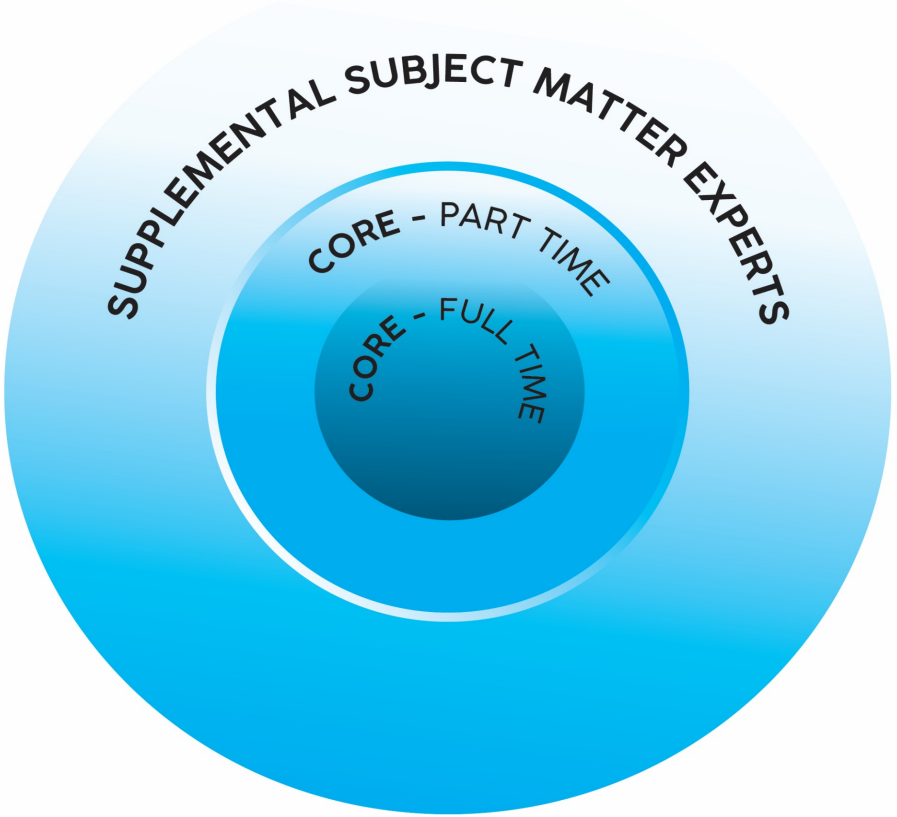
No SER

Write SER

- Integrated approach to reasonable assurance of adequate protection
- Environmental reviews

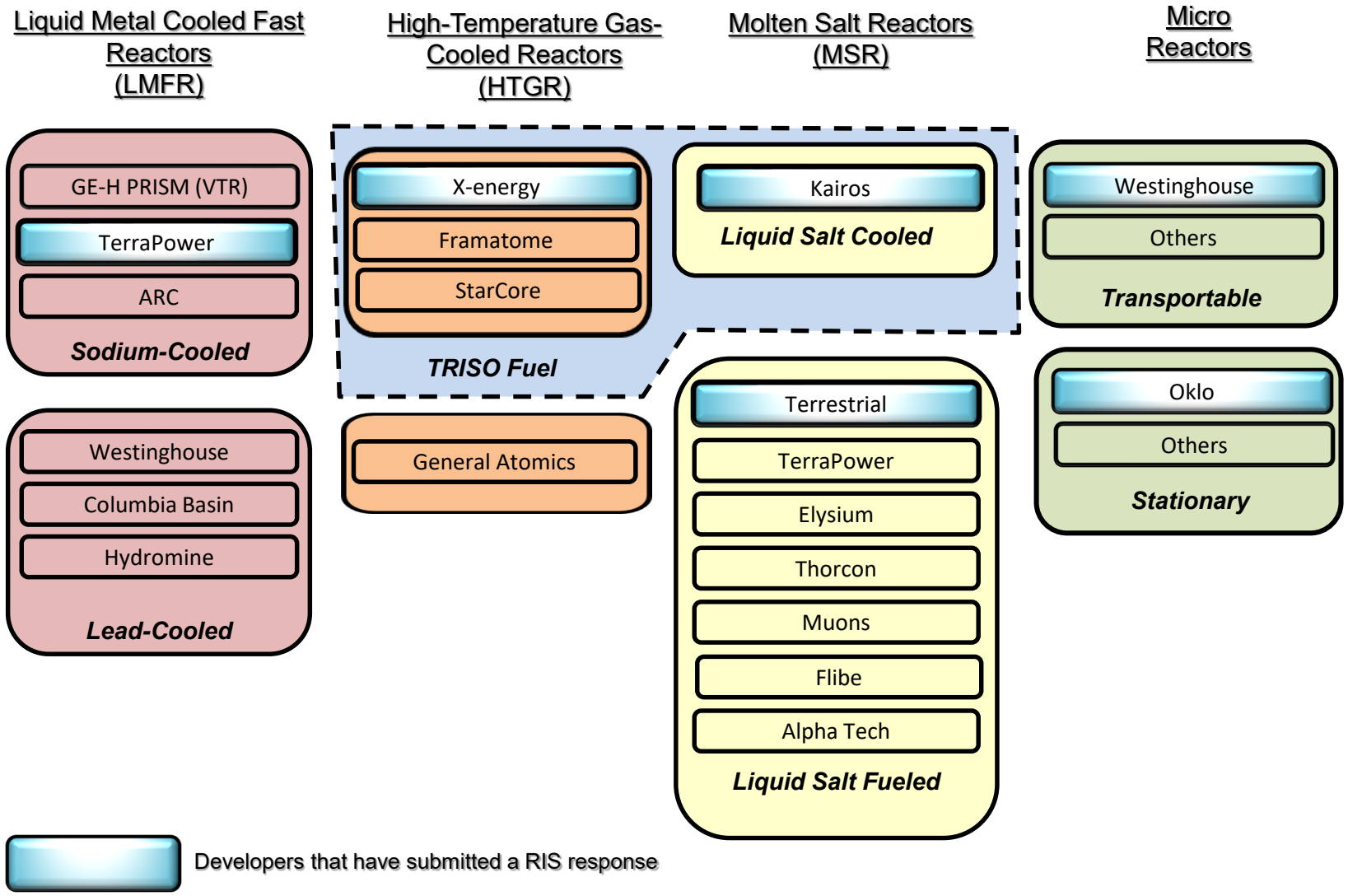
Readiness: Project Team

OKLO INTEGRATED REVIEW — PROJECT TEAM STRUCTURE

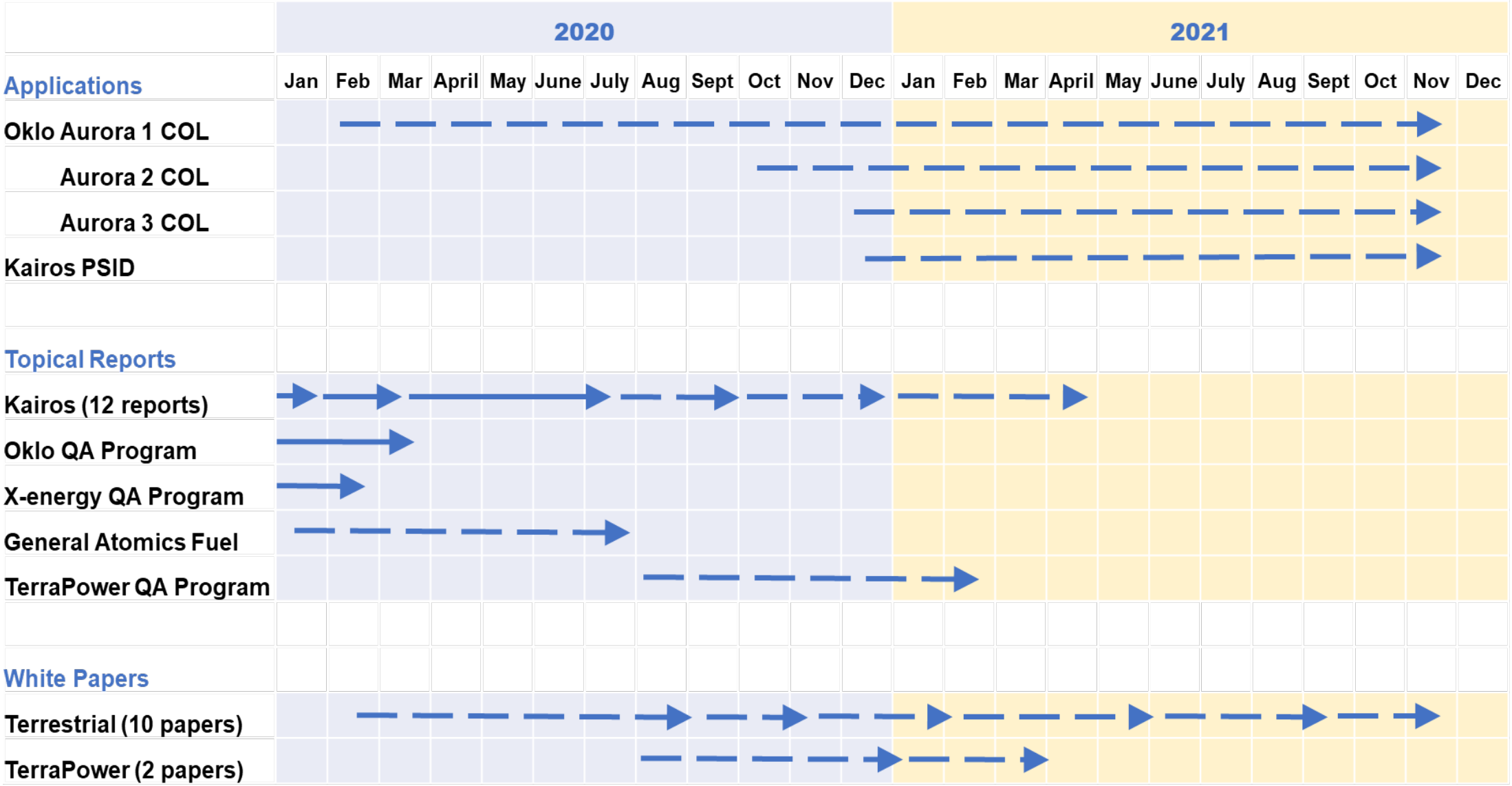


Color gradient denotes level of effort

Potential Applicants



Current and Anticipated Work



Oklo Review Status

Photo Courtesy of Oklo, Inc

Oklo Aurora Powerhouse

Acronyms

- **AOO** – anticipated operational occurrence
- **BDBE** – beyond design basis event
- **CFR** – Code of Federal Regulations
- **COL** – combined license
- **DBA** – design basis accident
- **DBE** – design basis event
- **DG** – draft guide
- **GE-H** – GE Hitachi Nuclear Energy
- **HTGR** – high-temperature gas-cooled reactor

Acronyms

- **ICN** – ITAAC closure notification
- **ITAAC** – inspections, tests, analyses, and acceptance criteria
- **LAR** – license amendment request
- **MSR** – molten salt reactor
- **NEICA** – Nuclear Energy Innovation Capabilities Act
- **NEIMA** – Nuclear Energy Innovation and Modernization Act
- **NRR** – Office of Nuclear Reactor Regulation
- **LMP** – licensing modernization project

Acronyms

- **LMFR** – liquid metal cooled fast reactor
- **LWR** – light-water reactor
- **NEI** – Nuclear Energy Institute
- **NRC** – U.S. Nuclear Regulatory Commission
- **QA** – quality assurance
- **PISD** – preliminary safety information document
- **RIS** – regulatory issue summary
- **SER** – safety evaluation report
- **SMR** – small modular reactor

Acronyms

- **SSC** – systems, structures and components
- **TRISO** – tristructural-isotropic
- **UAMPS** – Utah Associated Municipal Power Systems
- **UIN** – uncompleted ITAAC notification
- **VPO** – Vogtle Project Office
- **VRG** – Vogtle Readiness Group
- **VTR** – versatile test reactor
- **WGSAR** – Working Group on the Safety of Advanced Reactors